

print

Faculty of Science

University of Zagreb



On September 23rd, 1669. Leopold I certified at the Jesuit Neoacademia Zagrebiensis, a three-year higher education institution, which gradually developed the studies of Philosophy, Law and Theology. At the Jesuit School philosophy was taught even earlier, and part of its first year studies were Logic, "Physics", and Metaphysics. Neither Jesuit School (until 1773), nor royal Regia Scientiarum Academica (until 1850) represented a real university. Croatian Sabor (House of Representatives) and King Franjo Josip I, introduced the Law on founding the University of Zagreb. Soon after the establishing of the University of Zagreb, Faculties of Law, Theology and Philosophy started operating. The Chairs of the Faculty of Philosophy were appointed gradually. In the field of natural sciences the teaching started in 1876, with first lectures in mineralogy and geology, and then in botanic, physics, mathematics, chemistry and zoology and geography. A long endeavour of the Science Department of the Faculty of Philosophy to attain the status of Faculty finally materialized in 1946, when the Faculty of Science was established.

The Faculty includes 7 departments, the Seismological Service, the Mareographic and Meteorological stations, and the Botanical garden. The Faculty has 288 full professors, associate and assistant professors, over 180 junior researchers and about 5000 students. The Faculty offers undergraduate, graduate, and postgraduate study programs, and pursues research in the fields of natural sciences and mathematics. The Faculty of Science is engaged in excellent cooperation with numerous universities and institutes abroad. Professors of the Faculty have been invited as visiting lecturers to European and American universities, and young staff members, as well as postgraduate students, are regularly sent to international universities and institutes for further research.

The Faculty of Science has 8 undergraduate study programs (Bachelor degree) encompassing 3 years of studies (180 credits), 26 graduate study programs (Master degree) encompassing 2 years of studies (120 credits) or 5 years of studies (300 credits) and 7 postgraduate study programs (PhD degree) encompassing 3 years of studies (180 credits). Education is at all levels characterized by teaching and supervision at a high academic level by staff actively involved in research. Departments of the Faculty are placed on several locations in Zagreb. The departments of Physics, Mathematics, Geophysics, Chemistry, Geology, and the main administration of the Faculty are set at Horvatovac where a "campus of science" is being built. Departments of Biology and Geography are also going to be set at the same location in the near future. The education of students in science and mathematics is a part of a comprehensive science education that qualifies them to work in research institutes, different branches of industry and production, the civil service (environmental protection, regional planning), public institutions (national parks, nature parks, reserves) and elsewhere, or as teachers in primary, secondary, and vocational schools.

All the academic staff is actively involved in research carried out at high international standards. They are supported by postgraduates and research personnel from seven departments. They work across the whole spectrum of scientific activities ranging from basic to applied research and many have been recognized internationally for their contributions to research and development.

Department of Mathematics

ORGANIZATIONAL STRUCTURE

Institute for algebra and the foundations of mathematics

Institute for applied mathematics

Institute for computer science

Institute for geometry

Institute for mathematical analysis

Institute for numerical mathematics and scientific computing

Institute for the theory of probability and mathematical statistics

Institute for topology

Professorship for didactics of teaching mathematics and computer science

Computing centre

Central mathematical library

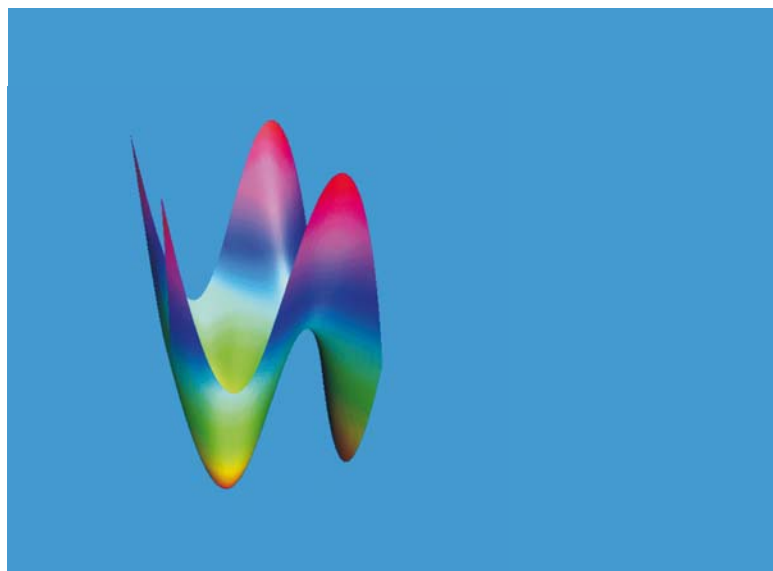
MISSION Department of Mathematics is the leading institution in Croatia which develops teaching and research excellence in mathematical sciences. The Department develops new study programmes in the area of mathematical sciences and their applications adapting to the needs of the Croatian economy. Department of Mathematics gives analytical support for the development of advanced technologies. Department of Mathematics performs quantitative research in the interest of society.

VISION We see Mathematical sciences as an interesting and central part of the general culture of a society based on knowledge. Department of Mathematics will actively work with high schools to make learning mathematics more attractive and more acceptable to general public. Department of Mathematics will develop into the leading mathematical institution in the wider region. Department of Mathematics will position itself within the Croatian academic and technology network as the top institution for providing analytical services in quantitative analysis. Department of Mathematics will stimulate transfer of technology, both through educational as well as scientific processes, towards small and medium-sized companies that develop advanced technologies.

DESCRIPTION OF THE DEPARTMENT The Department of Mathematics currently employs 58 professors (of which one is an academician), 39 junior researchers and about 20 associates on 8 institutes in total. In average there are 1700 students in 12 different under/post/graduate programmes. Computing centre keeps educational—scientific equipment in seminar rooms, lecture rooms and computer labs and it develops software support both for the needs of teaching and administrative services. Professorship for the didactics of teaching mathematics and computer science coordinates scientific and professional research in the education of mathematics. One of its duties is to explore possibilities of getting mathematics and computer science more popular on all levels of education in Croatia.

CENTRAL MATHEMATICAL LIBRARY Central mathematical library has its origins in the Reading room of the Croatian mathematical and physical society. The reading room was opened to the public in 1949. Major additions to the library were made by merging the funds of the libraries of Mathematical institute, Institute for applied mathematics and Institute for geometry of the Faculty of Science and mathematics with the fund of the library of the Institute for mathematics of the Faculty of Electrical Engineering. In the 2010 the funds of the library included: over 30.000 books and 800 magazines, 310 of which are current.

Bijenička cesta 30
HR-10000 Zagreb, Croatia
Tel: +385-1-4605 777
<http://www.pmf.unizg.hr/math>



Department of Mathematics – scientific activities

With almost 60 professors Department of Mathematics is the central and the largest mathematical research institution in Croatia. The scientific activity of our researchers does not just follow but leads and sets general trends in Croatian science. In the computer age, mathematical competences are fundamental not only for all natural and technical sciences, but also for biomedical and a large part of social sciences. Notably, wherever there is a need for quantitative methods there is a place for a mathematician. Scientific activity takes place through 30 projects financed by Ministry of science education and sports. This represents a half of all scientific projects in mathematics in Croatia. The researchers from the Department of Mathematics also participate in several European and bilateral (state sponsored) projects. About a quarter of active scientists in field of mathematics are employed at our Department. Research activities at the Department are organized in 8 workgroups (seminars). Roughly speaking, scientific activity can be divided in 3 areas: pure mathematics, applied mathematics and computer science. Only during last year members of our Department published over 120 scientific papers in international journals, over 75 of which are from the Impact factor list. They also gave over 50 lectures on international scientific conferences. Department of Mathematics and its professors organized or participated in organization of many international conferences.

Pure mathematics Scientific activities in pure mathematics cover different fields of mathematics, from algebra, number theory, functional analysis, dynamic systems, partial differential equations, topology, probability theory, theory of representation, discrete mathematics to algebraic geometry. They are very important for themselves but also present foundation for other activities in applied mathematics and scientific computing. Researchers in these areas publish

in highly esteemed journals like Memoirs of the American Mathematical Society, Journal of the American Mathematical Society, International Mathematical Research Notices, and Israel Journal of Mathematics etc. They developed also a collaboration with prominent world institutions like Erwin Schrodinger Institute (Wien), ETH (Zurich), Institute de Mathematiques de Jussiez (Paris), University Louis Pasteur (Strasbourg), University of Utah (Salt Lake City), Cornell University (Ithaca), University of Illinois (Urbana-Champaign), Universities in Graz, Debrecen, Singapore, Hong Kong, Kyoto, Dresden, Peking etc. For their distinguished scientific activity we particularly mention group for theory of representations. Due to their merits Zagreb is today considered as one of the prominent centres for this research in this area in the world.

Applied Mathematics Research in applied mathematics constitutes an important part of scientific activity of the Department of Mathematics. Activities in this area are numerous and we mention only a few: numerical linear algebra, fluid mechanics, theory of elasticity, statistics, biostatistics, financial mathematics, mathematical biology, numerical analysis, ordinary and partial differential equation, decision theory, computational molecular biology, wavelets, data mining, etc. Many of the scientists from Department of Mathematics collaborated in projects related to industry (pharmaceutical, energy, oil, and chemical industries), telecommunications, navigation, cartography, water management, finance and medical industries, to mention just the most prominent collaborations. Their scientific papers are published in prestigious journals like those published by SIAM (Society for Industrial and Applied Mathematics), but also, Stochastic Processes and Applications, Archive for Rational Mechanics and Analysis, Mathematical Models and Methods in the Applied Sciences, Nonlinearity, Nonlinear Analysis, Real World Applications, Numerische Mathematik, Annals of Applied Probability etc. Additionally they have developed significant collaboration with many institutions abroad like ETH (Zurich), Max Planck Institute (Leipzig), ANDRA (Paris), Universities in Aachen, Lyon, Moscow, Houston, Pau and Boulder.

Computer science and information technologies

The development of distributed algorithms for finding optimal path in a graph is one of the most important activities in the area of computer science and its applications. Path finding algorithms have direct applications in modelling of computer networks, telecommunications and various navigational problems. The results in the area of data compression and data mining are another important contribution in this area. We would like to stress the interactions between computer science and other areas of mathematics, especially applied mathematics. In this interdisciplinary research area we include contributions that our experts in numerical mathematics gave in developing numerical software package LAPACK, but also activities in the area of decision theory and computational biology, computational mechanics, physics and geophysics. Papers from computer science research groups are published in distinguished international journals like ACM Transactions on Mathematical Software, AMS Mathematics of Computation,

telematic solutions (that is integrated use of telecommunications and ICT) in street navigation. The project will unify activities of the groups for discrete mathematics and mathematical statistics with the activities of the research group developing modern mathematical software.

On the other side, the problem of the safe communication through an unsafe communication channel connects activities of the researchers from pure mathematics with practitioners that develop modern information systems. Methods that have usually been used during history for encrypting messages were the substitution and transposition of the basic elements of text (letters, blocks of letters, binary digits). A combination of these two methods, can be found today even in the most modern symmetrical cryptosystems. Asymmetrical cryptosystems or cryptosystems with public key appeared in the 70's. For encryption they use functions which are "unilateral" (they are easily computed, but their inversion is very difficult). It means that the function for encrypting can be public, while



SIAM Journal on Scientific Computing, Informatica, Journal of Computing and Information Technology-CIT, Ars Combinatoria, to mention the most prominent journals.

Synergies in developing solutions for development of information technologies

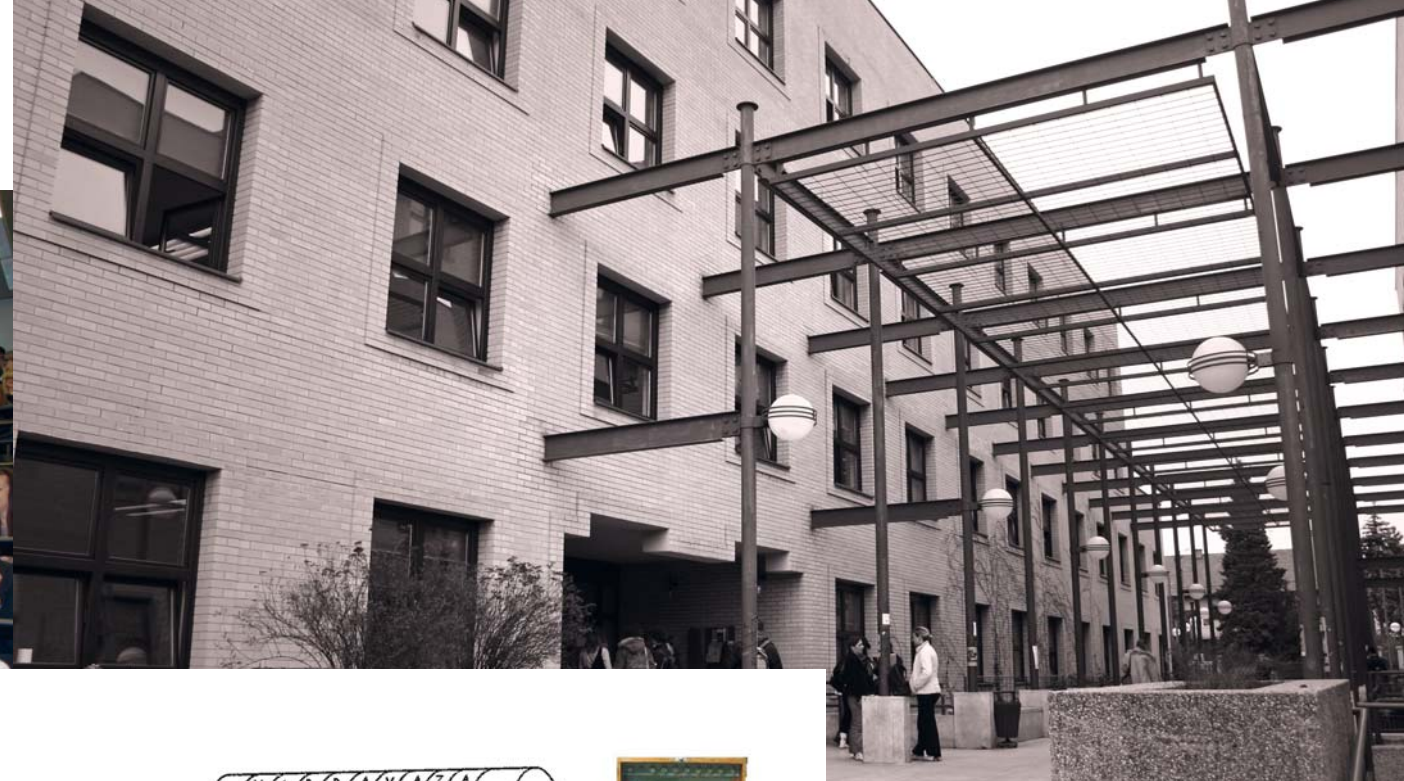
In the area of application of mathematics in developing information technologies there is a synergy of all of the workgroups at the department.

In the area of application of mathematics in developing computer science and information technologies there is a collaboration of the Department of Mathematics with Croatian companies that develop advanced technology. Within the project of development of a vectorized map of Adriatic our experts helped develop a method to approximate the Croatian coastline so that the error of the approximation is smaller than the error of the GPS system. There is currently one junior researcher at the Department working on the common technological project which is completely financed by a private company. The goal of this project is to propose innovations in area of providing

only a function for decryption must be secret. The structure of unilateral function is based on "hard" mathematical problems, like factorization of large natural numbers, and logarithms in finite groups.

In addition, employees of the department gave important contributions in applications that range from problems of identification of vessels when controlling the sea border to analytical support in developing pension fund reform, initiated by negative demographic trends in the society.

With those activities we work on realisation of our vision of the department which will position itself within the Croatian technology and research network as the leading institution for providing analytical services in quantitative analysis.



Department of Mathematics – teaching activities

Mathematics is and was one of the fundamental sciences for the development of human civilization. It grew out of everyday needs of old Egyptians in 20th Century B.C. (counting of various object, land measuring, construction of dwellings, understanding celestial phenomena, navigational problems at sea, the beginnings of trade and barter), which lead to deliberation on the relationship of sizes and the study of the shapes of space. Today, mathematics represents “the queen of all sciences”, developing powerfully and rapidly over enormously wide and complex field of research and application with a considerable number of scientist and experts. Its importance in contemporary society is reflected by the fact that, besides native language, mathematics is the most represented school subject in almost all schools all over the world.

According to our mission, Department of Mathematics develops study programmes that answer current needs of the Croatian economy for experts who have special knowledge in mathematical sciences. Our total 12 study programmes can be divided in the following categories:

Education of mathematics

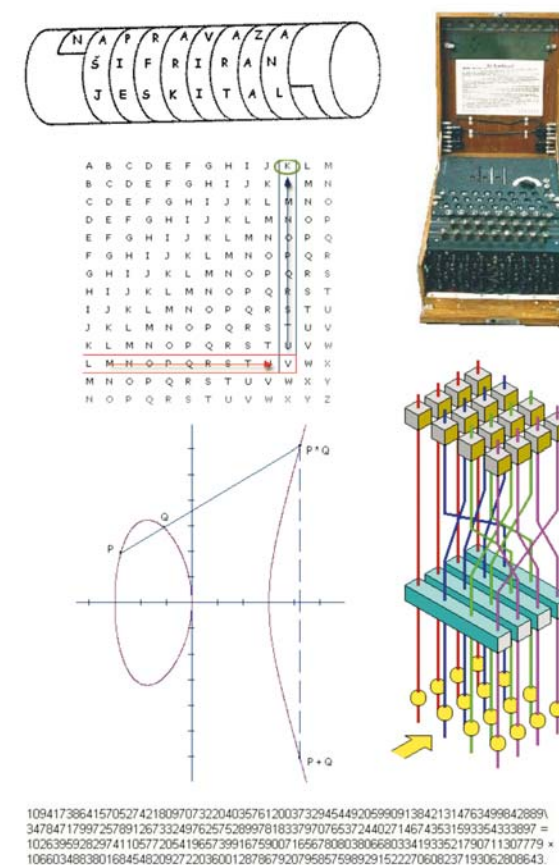
University Undergraduate Programme in Mathematics Education is the fundamental higher education study programme in the area of mathematics, information—communication technologies (ICT) and educational sciences. Bachelors of Education in Mathematics do not have, without finishing the corresponding graduate programme, necessary technical and didactical competences for teaching mathematics and ICT at the elementary and high school level. However, they are qualified for various technical professions and other jobs that require an analytical way of thinking, fundamental knowledge in the area of mathematics and computer science and a capability of mathematical modelling of problems. Furthermore, they have

knowledge of statistics, as well as competence in organization and presentation of data and advanced applications of ICT. University Graduate Programme in Mathematics Education and the University Graduate Programme in Mathematics and Computer Science Education give students the university-level education in mathematics and computer science. They also give the professional and didactic competence to teach all programmes in mathematics and informatics at the elementary and secondary school level. It further prepares the candidates for all other tasks (e.g. administrative) which they are going to have as teachers in elementary and secondary schools. Upon completing this programme the students acquire the academic title Master of Education in Mathematics. Masters of Education in Mathematics are also qualified for various jobs in industry, public administration and research community. Let us stress that they have, through their training in educational sciences, good foundation for developing advanced social and presentational competences.

Integrated Undergraduate and Graduate Programme in Mathematics and Physics Education gives students the necessary technical, didactical and pedagogical competences for efficient realization of every educational programme in the area of mathematics and physics education at elementary and high school level. Masters of Education in Mathematics and Physics are especially prepared for working with groups of students who have special needs such as: helping students who have learning difficulties when adapting to the standard programmes in state education system as well as preparing students for competitions in mathematics and physics at all levels.

Study of mathematics and its applications

University Undergraduate Programme in Mathematics is primarily conceived as the first of the two cycles of university education of expert mathematicians (3 + 2 system); in other words, as the first step in acquiring the academic title Master of Science in Mathematics. This course also offers necessary expertise for various technical jobs and occupations in finance industry and public administration. The students are especially prepared for jobs which require analytical way of thinking, basic



knowledge in mathematics and computer science, and the ability for mathematical modelling. The students also have knowledge of statistics, numerical mathematics, computer science and advanced applications of ICT such as use of multimedia. The second stage of education is one of five graduate programmes which lead to the academic title Master of Science in Mathematics and Master of Science in Computer Science and Mathematics. These graduates are qualified for an employment in science and higher education system (universities and research institutes—e.g. technical, economics and polytechnic), as collaborators (assistant, junior research assistant, expert collaborator) in the field of mathematics, and to start their own research in that field.

University Graduate Programme in Pure Mathematics, with its study topics and methods of teaching, enables students to acquire basic background and understanding of results in the field of pure mathematics and introduces them to most important classical and some modern mathematical disciplines and their theories. In this course of study, students become familiar with the classical and contemporary accomplishments of algebra and the foundations of mathematics, mathematical analysis, probability theory, geometry, and topology, as well as with some areas of applied mathematics such as differential equations and other sciences which are closely connected with mathematics.

We will now list other graduate programmes in mathematics together with additional qualifications which they give to the students.

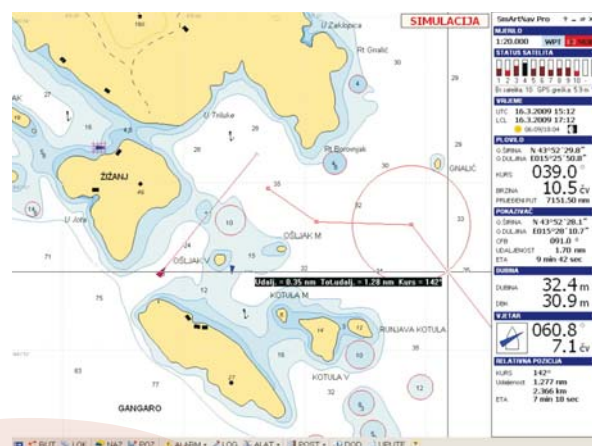
University Graduate Programme in Applied Mathematics additionally qualifies for an employment as a collaborator in research projects in the interdisciplinary area where mathematics is applied in other sciences (natural sciences, technical sciences, economic sciences, medicine, etc.). Specifically it qualifies for professions where competences in mathematical modelling and application of analytical and numerical methods in other professions are needed.

University Graduate Programme in Mathematical Statistics additionally qualifies for an employment as a collaborator in research projects in the interdisciplinary area where theory of probability and mathematical statistics is applied in other scientific fields (natural sciences, technical sciences, humanities, economics, medicine, technology etc.). Also, it qualifies for an employed in economic sector as quantitative researcher, quality controller, analyst and actuary (in banks, pension funds, insurance companies), and in public administration as statistician (in Croatian Bureau of Statistics, Health Sector) and similar.

University Graduate Programme in Financial and Business Mathematics additionally qualifies for an employment in insurance companies (actuaries), banks, stock-exchanges and broker houses (risk analysis, securities' analysis, asset management), pension and health funds, government offices and agencies.

University Graduate Programme in Computer Science and Mathematics additionally qualifies for an employment as software engineers, working on software development or the development of information systems, foremost in companies that specialise in information and communications technology. In addition, they can work as entrance-level experts or researchers for industrial institutions on research and development projects, especially if such projects require the intensive and innovative application of information and communications technology. Finally, graduates with the degree of Master of Computer Science and Mathematics can be information scientists in the state administration or in public services, who work on the development and maintenance of state and public information systems.

All of the mentioned professions are deficient, i.e. there is the constant demand for such professionals on the job market.



Postgraduate programmes

Department of Mathematics is the coordinating institution of the Croatian Doctoral Programme in Mathematics. This programme is the joint effort of the Universities of Osijek, Rijeka, Split and Zagreb. It is the only doctoral programme in mathematics in Croatia. After successful completion of the three year study programme and the defence of the doctoral theses the students acquire the title of the Doctor of Science in Mathematics. This postgraduate programme is adapted for the mobility of students and professors. Within the programme there are 22 different postgraduate seminars which give candidates the contact with modern achievements from a wide spectre of mathematical areas and applications of mathematics. Department of Mathematics, in cooperation with the Croatian Actuarial Association, offers a two year Postgraduate Program in Actuarial Mathematics. The program includes writing of the master thesis and leads to the title Master of Actuarial Mathematics.

The master program follows the current program cores adopted by IAA (International Actuarial Association) and Groupe Consultatif (des Associations d'Actuaries des Pays de Communautés Européennes). Students are expected to have mathematical knowledge comparable to an undergraduate degree in mathematics, physics or engineering. The program is designed towards the needs of students already employed in the insurance industry - insurance companies, pension funds and government agencies.

Department of Mathematics – other activities

Reviews of the University of Zagreb Department of Mathematics regularly presents its activities at the Reviews of the University of Zagreb. The presentation of the Department has evolved, since the beginning of the reviews in 1995, into one of the most visited displays on the Review. Presentations are organised so that they offer all the necessary information about possibilities of studying at the Department as well as to enable all visitors of the Review to familiarize with various kinds of entertaining and/or applied mathematics. The emphasis is placed on active participation of visitors in playing mathematical games and in solving problems.

The day of open doors The day of open doors at the Department of Mathematics takes place every year in May after the graduation in Croatian high schools. The goal is that those students who are interested in enrolment in one of the programmes at the Department of Mathematics get detailed information about possibilities and prerequisites for studying at the Department. Through direct conversation with teachers and students of the Department they can get the answers on any specific enrolment question. In 2008, during the day of open doors, we organized the workshop named "Hocus pocus mathematicus", on which visitors could participate in several magical tricks based on mathematics.

Workshops and popular lectures In 2008, we organized 4 popular mathematical workshops named "Mathematical origami" which were intended for elementary school pupils. We plan other similar workshops. Section for the industrial mathematics of the Croatian Mathematical Society regularly holds colloquia related to applications of mathematics. The colloquia are intended not only for experts but also for general population. The schedule of lectures and information on activities of this Section can be found on the web page http://www.matematika.hr/inzenjerska_sek. Educational section of Croatian Mathematical Society regularly organizes lectures for the continuous education of state school teachers. Some of them address topics in popular mathematics and are aimed at general public. Department of Mathematics in collaboration with Grammar School V (Zagreb) organizes popular mathematical lessons for high school students named "CoolMath" (till now 24 of them were held).

Publishing activity The building of the Department also hosts Croatian Mathematical Society which has large publishing activity. Department of Mathematics, together with Croatian mathematical society, publishes scientific journal Glasnik Matematički. Glasnik Matematički is the oldest Croatian mathematical journal. It is indexed in Science Citation Index Expanded (SCIE) and Web of Science (WoS). Besides publishing scientific and popular journals and conference proceedings the Department publishes teaching scripts, textbooks and other learning material.

Department of Physics

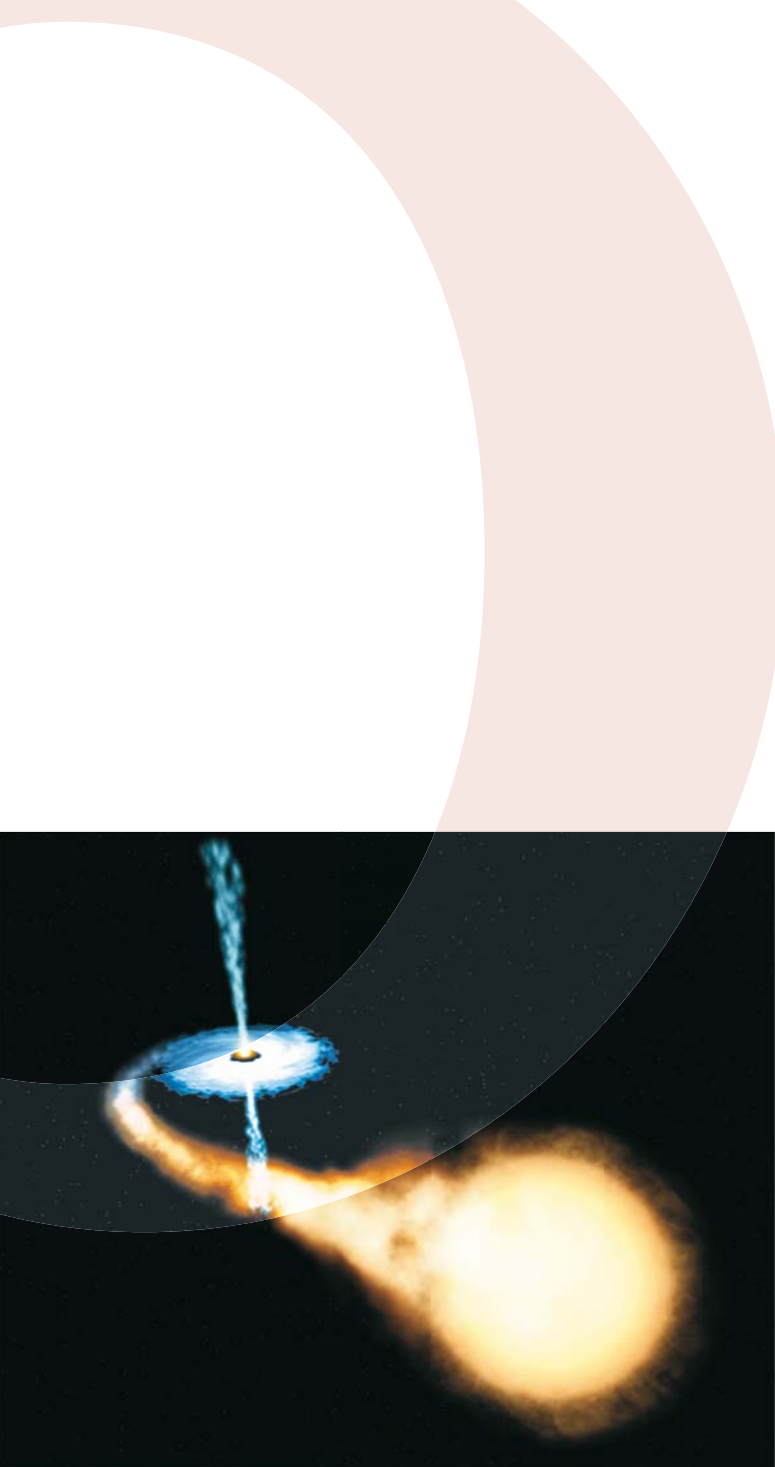
MISSION The mission of the Department is to investigate and interpret material phenomena, by theoretical and experimental methods, based on a fundamental understanding of the underlying physical laws. Top-level training in physics is integrated with current research, having the purpose to prepare students facing the challenges of contemporary science, technological and economic development, and education of younger generations.

VISION The Department should strengthen its position as the central institution for physics at the University of Zagreb, licenced for the postgraduate doctoral study in physics, and for approving the selection and promotion of junior and senior professors of physics. The Department is to maintain an internationally recognised quality and, by virtue of such reputation, to effectively look after the status of physics in the Croatian society in general, and particularly in the education system of the Republic of Croatia.

DESCRIPTION OF THE DEPARTMENT The current academic staff of the Department consist of 45 Professors (including 3 Academicians and 2 Professors Emeritus), 33 junior researchers, and 11 Assistants and Lecturers. There are about 650 students enrolled in 6 programmes of the integral undergraduate and graduate study of physics (research physics, educational physics, educational physics and computer science, educational physics and technology, educational physics and chemistry, educational mathematics and physics) and 40 students in the postgraduate doctoral study in physics. Departmental teaching facilities include 2 lecture halls, 4 medium classrooms, library, 2 computer labs, 7 student laboratory (practicum) classrooms, and a dozen of advanced research laboratories.

CENTRAL PHYSICS LIBRARY The Central Physics Library was founded in 1990 by merging the libraries of the Department's divisions, among which the oldest was established in 1876 (the Library of the Physics Division). The library contains over 50000 volumes (books, journals, theses, etc.). Various services are provided to users of the Library, including electronic access to scientific information.

Bijenička cesta 32
HR-10000 Zagreb, Croatia
Tel: +385-1-4605 555
<http://www.pmf.unizg.hr/phy>

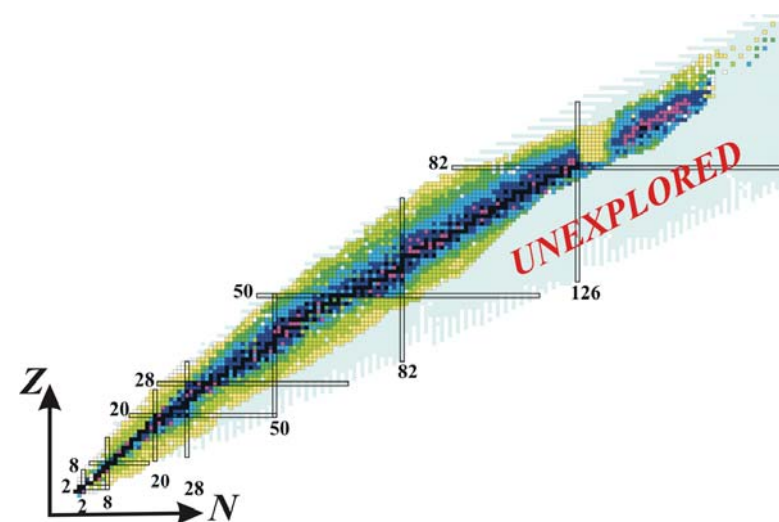


Department of Physics – scientific activities

Physics of elementary particles The theoretical research is performed in the field of elementary particle interactions in the framework of the Standard Model (SM) and its generalizations, in astroparticle physics and cosmology, in classical and quantum gravity and in theories of unification. Investigations of symmetries in the electroweak sector, such as CP violation and lepton number violation, give an insight into directions in which the SM should be generalized, and simultaneously call for new particle degrees of freedom which provide cosmological dark matter candidates. Perturbative QCD is used for the description of hadronic properties in terms of quarks and gluons and (generalized) parton distributions. Nonperturbative QCD is treated by means of coupled system of Schwinger-Dyson and Bethe-Salpeter equations in vacuum

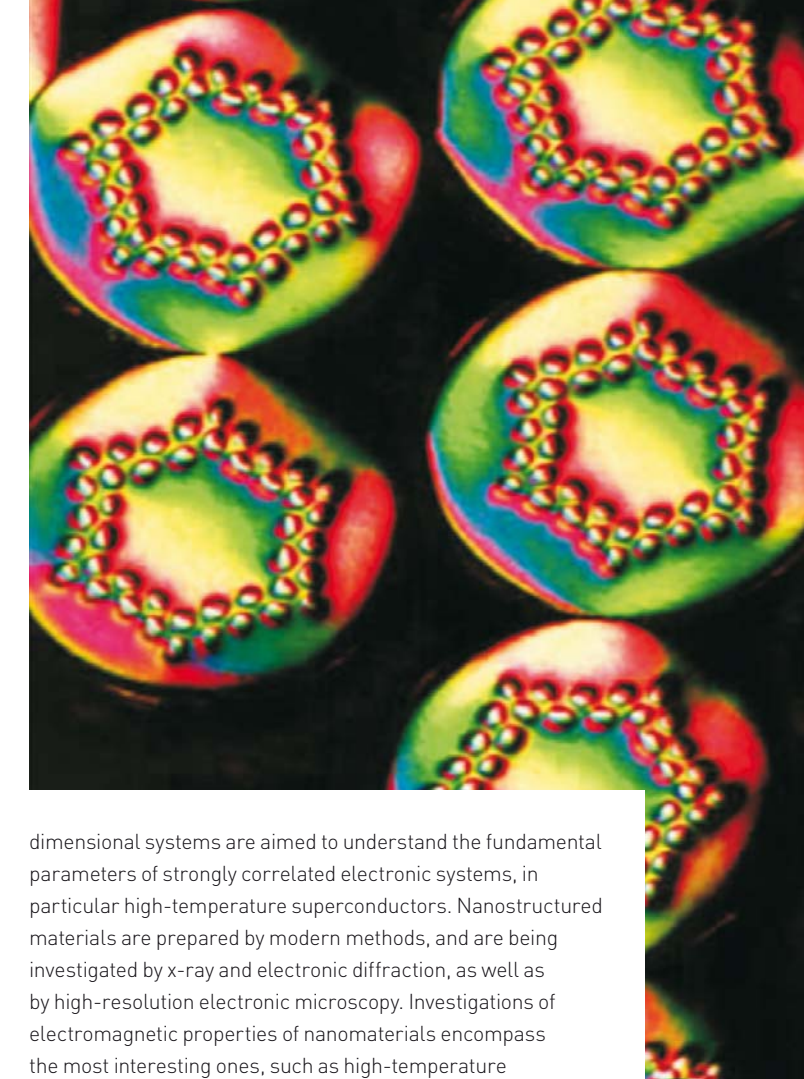
and at finite temperature. Microscopic origin of black hole is studied within conformal field theory which is expected to be valid near the horizon. Alternative study relies on the string theory, which is believed to be a consistent theory of quantum gravity. Experimentally contributions of gluons and sea quarks to proton spin in collisions of polarized proton beams are probed at energies where Quantum Chromodynamics (QCD) can be applied perturbatively to describe hard nucleon collisions. Origin of the big transverse spin asymmetries in forward neutral pion production is studied in measurements with transversely polarized proton beams at RHIC accelerator.

Nuclear physics Theoretical studies are mainly focused toward nuclear structure and nuclear astrophysics, aiming to describe finite nuclei and nuclear matter starting from the fundamental understanding of effective nucleon-nucleon interactions. In particular, these include the development of a microscopic theory of nuclear structure based on covariant energy density functionals and effective field theory, the description of the structure of exotic nuclei far from the valley of stability, the investigation of the connection between



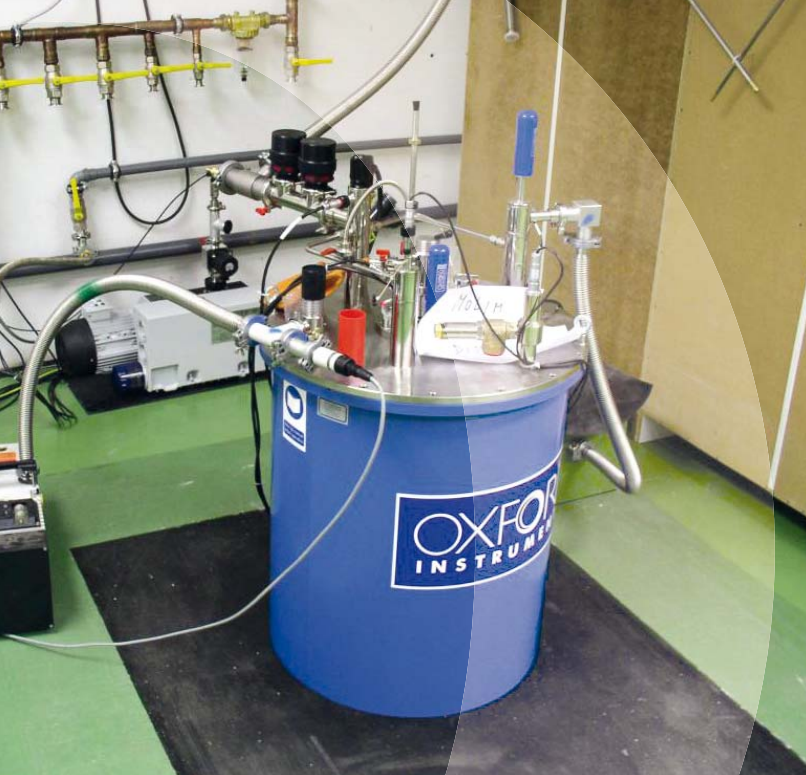
non-perturbative QCD in the low-energy limit and the rich phenomenology of the nuclear many-body system, studies of exotic modes of excitation in unstable nuclei, and the modeling of weak-interactions of neutrinos and charged leptons with nuclei and their role in astrophysical processes (in the framework of an UKF project with international collaboration agreements). Experimentally the hadronic systems are studied in medium and high energy accelerators, with the aim of studying the formation and characteristics of quark-gluon plasma, which allows understanding of the early universe, and better understanding of nucleon-nucleon interaction through the hypernuclear program. Electroproduction of hypernuclei allows spectroscopy of nuclear levels affected by the presence of strangeness, which closely connects the experimental knowledge about the nucleon-hyperon interaction with existing knowledge of the nucleon-nucleon interaction.

Condensed matter physics New materials are being developed and investigated, characterized by low dimensionality and special structures at the nanometer scale, as well as being dominated by quantum effects. Their conceptual interest and possible applications put them in the focus of interest of the world scientific and technological community. Efforts are made to control the whole research process, from sample synthesis to measurement and interpretation of results, and back, with the aim to advance fundamental understanding of their topological, structural, thermodynamic, electrical, microwave and optical properties. Materials research is grouped in three main directions: spin (magnetic) response, charge response, and effects of nanostructure or disorder. Investigations of nanomagnets encompass magnetic nanoparticles, single-molecule magnets and magnetic clusters within magnetic matrices, to improve understanding of the influence of parameters and of macroscopic quantum tunneling. Investigations of systems with spatial and dimensional restrictions encompass the electrical, magnetotransport and magnetic properties of layered metal nanomagnetic structures (spin valves), dilute magnetic oxide systems, organic chain conductors and anorganic chain and ladder oxide systems. Microwave investigations of low-



dimensional systems are aimed to understand the fundamental parameters of strongly correlated electronic systems, in particular high-temperature superconductors. Nanostructured materials are prepared by modern methods, and are being investigated by x-ray and electronic diffraction, as well as by high-resolution electronic microscopy. Investigations of electromagnetic properties of nanomaterials encompass the most interesting ones, such as high-temperature superconductors, amorphous and nanocrystalline metal-metal alloys, and organic conductors, with a view to understand the role of synthesis parameters on nanostructural details, and the influence of electronic correlations on electric, magnetic, and thermodynamic properties. Theoretical investigations are focussed on the understanding of behavior of high-temperature superconductors in the same three groups of measurements, and on the elucidation of the mechanism of high-temperature superconductivity. Electronic and optical properties of artificially fabricated systems of low dimensionality and nanoscopic size are also under investigation [electronic structure and excitations of thin metal films and heterostructures, tunneling and electronic current in nanostructures, the structure and mechanical properties of nanoparticles and nanowires, etc.], with an aim to elucidate their fundamental properties. The Department of Physics also became the coordinator of the SOLeNeMaR project within the 7th framework program of the EU for research and technological development, which introduced the experimental technique of nuclear magnetic resonance for solid state physics as a highly valuable technique to investigate the local properties of all the above-mentioned materials

Atomic and molecular physics, astrophysics In atomic and molecular physics and plasma spectroscopy current research is oriented towards determination of atomic interaction potentials, specifically - interactions between two neutral atoms and also between neutral atoms and electrons and/or ions. The details of atomic interactions are determined measuring the shift and the width as well as the shape of atomic and molecular lines. Experimental results give shift and broadening parameters which could be compared to



the corresponding theoretical data. Experiments comprise laser spectroscopy and classical spectroscopic techniques and methods. Theoretical studies of nonlinear phenomena and wave dynamics in photonic systems encompass the effects of wave coherence on nonlinear phenomena such as solitons, modulation instability, and wave dynamics in general. Nonequilibrium dynamics of exactly solvable one-dimensional models such as the Lieb-Liniger and Tonks-Girardeau models, which were recently experimentally realized with ultracold atoms in tight atomic wave guides, is aimed at better understanding of nonequilibrium phenomena and providing benchmarks for versatile approximations. A recent topic of interest focuses on the optical properties of graphene and its possible use for plasmonics. Research in astrophysics is devoted to the topics of stellar structure and evolution. In particular, emphasis is given to an empirical probing of the recent theoretical evolutionary models which incorporates the effects of rotationally induced turbulent mixing of stellar material. The final goal is to trace chemical evolution of the components in close binary stars.

Biophysics and bioinformatics Neurobiophysics research aims at examining cognitive neurodynamics of face processing using magnetoencephalographic (MEG) measurements and numerical simulations to obtain insight into cortical dynamics of sensory and cognitive processes of the human brain. The analysis of auditory neuromagnetic responses is used to examine to what extent conditions such as Mild Cognitive Impairment (MCI) and Alzheimer's disease (AD) induce the changes in the cortical dynamics of the auditory cortex and if they can be used a pre-clinical biomarker. In the field of bioinformatics, investigations of chromosome specific higher order repeats (HORs), very large repeats (tandem and dispersed) and duplicons in human genome are performed using our new computational method Global Repeat Map (GRM) based on Key String Algorithm (KSA), which is more robust than the standard bioinformatics methods, thus enabling discovery of new, as yet unknown higher order repeats. These results are used for new insights into evolutionary genomics and medical genetics.



Physics education research, history and philosophy of physics Physics education research is focused on diagnosing of student difficulties in physics learning, assessment of the level of student conceptual understanding which is typically achieved through instruction and the development of constructivist-oriented teaching materials. Historical and philosophical studies are concerned with a variety of topics pertaining to the development and role of physics in Croatian society and the interpretation of quantum mechanics.

Department of Physics – teaching activities

Physics today Over its 2600 years long history the character and methods of physics have changed radically. However, its aim has remained the same: to grasp, by universal principles, the fundamental structure of the material world and to use these insights for the explanation of the broad range of everyday and experimental natural phenomena.



In that sense physics is the fundamental natural science, embracing the processes controlled by men through artefacts. Therefore, physics provides the basis for many fields of technology, as well as for the understanding of other natural sciences, and it has substantial influence on their progress. Many diagnostic methods in medicine are based on the techniques initially developed in physics. Laser stands among the greatest inventions used nowadays in communications, engineering, material processing, medicine, and other purposes. Thanks to brilliant theoretical and experimental breakthroughs, contemporary physics takes us far beyond everyday experience and concepts, confronting the human mind with greater challenges than ever before. Today we are striving to comprehend the strange behaviour of elementary particles - singly and bounded in structures like atoms, atomic nuclei or condensed matter - and the secrets of celestial



bodies, as well as the evolution and structure of the universe as a whole. University training in physics leads young people to the very heart of these exciting developments. It builds up clear, systematic, consistent and creative thinking, offers thrilling insights into the secrets of nature, and challenges us to participate in unveiling the structure of the world and in the application of physics in various human endeavours.

Integral undergraduate and graduate study of physics Research oriented study of physics is an integral undergraduate and graduate five-year study, demanding a full competence in theoretical and experimental physics, as well as the basic knowledge of mathematics and computer science. The students who complete the study obtain the degree "Master of Science in Physics" (mag. phys.). In order to gain the degree students need to collect 300 ECTS credits. The physics study is open to the transfer of students from related studies, but on condition of passing a differential exam. Masters of physics are competent to enrol in the postgraduate doctoral study of physics and they can find positions at universities, research institutes, medical institutions, nuclear power stations, industry, financial institutions, etc. During the first two years of the study students obtain basic theoretical and practical knowledge in physics, mathematics and computer science; at the third and the fourth year they get acquainted with theoretical methods in physics (electrodynamics, quantum and statistical physics) and take medium level courses in current fields of research (physics of elementary particles, nuclear physics, physics of condensed matter, astrophysics, experimental methods, etc.). They also have to choose at least 4 courses from a broad list of specialized subjects. In the fifth year, students choose courses depending on their career preference and spend a full semester working on a graduation thesis.

Educational studies The Department offers study in the following programmes: Master of Education in Physics (mag. educ. phys.), Master of Education in Physics and Computer Science (mag. educ. phys. et inf.), and Master of Education in Physics and Technology (mag. educ. phys. et techn.). All these studies are integral undergraduate and





graduate five-year studies, demanding a competence in physics (and computer science or technology respectively), as well as the basic knowledge of mathematics, pedagogy, psychology, general didactics and specific methods of teaching physics. In order to gain the degree, students need to collect 300 ECTS credits. Masters of education can find positions in primary and secondary schools.

Joint studies In collaboration with the Department of Chemistry, the Department offers study in the programme Master of Education in Physics and Chemistry (mag. educ. phys. et chem.). Also, in collaboration with the Department of Mathematics, the Department offers study in the programme Master of Education in Mathematics and Physics (mag. educ. math. et phys.). Both studies are integral undergraduate and graduate five-year studies. In order to gain the degree students need to collect 300 ECTS credits.

Doctoral studies In collaboration with the Department of Geophysics, the Department offers the postgraduate doctoral studies in physics, which qualify students for experimental or theoretical scientific research in the chosen field of physics. Therefore, the studies include both teaching and research components. Participation of teachers from other Croatian institutions has been envisaged, and visits of teachers from leading foreign universities and institutes are also possible. Research work is integrated into scientific projects of renowned laboratories and groups, and led by experienced mentors. To enrol in the study, a student must have completed a corresponding graduate study of physics. Candidates whose studies so far have not been in complete correspondence may enrol with the additional obligation to pass prescribed examinations. Upon completion of the doctoral studies in physics the students are competent for contemporary scientific research in physics.

The structure and the organization of the doctoral programme The study is composed as a regular three-year university course of study in several fields: Elementary particle physics, Nuclear physics, Condensed matter physics, Atomic and molecular physics and Astrophysics,

Biophysics, Medical physics, and Geophysics. In the course of the study a student should successfully complete all activities prescribed in the programme and acquire at least 180 ECTS points. In the first year the emphasis is on obligatory courses, while the participation in appropriately chosen elective courses shifts the emphasis towards full scientific research activity during the higher years. During the first two years the students may acquire 60 ECTS points by following the chosen courses and passing the requisite examinations. The remaining ECTS points should be acquired through scientific research and seminars during the second and the third year of the study, when each student takes part in the research activities of a chosen scientific research laboratory or group and in the scientific subject matter of the thesis advisor. In order to complete doctoral study, a student is required to defend doctoral thesis. The students who complete the study obtain the degree "Doctor of Natural Sciences in the Field of Physics" (Doctor scientiarum naturalium ad physicam pertinentium).

For students of other Departments Various courses in physics are organised at the Department for students of other Departments (of Mathematics, Chemistry, Biology, Geology, and Geophysics), and for other Faculties of the University of Zagreb.



Department of Chemistry

ORGANIZATIONAL STRUCTURE

Division of General and Inorganic Chemistry
Division of Physical Chemistry
Division of Analytical Chemistry
Division of Organic Chemistry
Division of Biochemistry

MISSION Department of Chemistry, as a component part of the Faculty of Science, offers scientific-research and teaching study programs in chemistry. The Department develops and carries out scientific-research programs, which are integrated in the educational process. Scientific and research work of the Department contributes to the development of chemical science as well as to the advancement of natural sciences and technology in the Republic of Croatia.

VISION Department of Chemistry is recognized as a leading institution marked by excellence both in scientific work and in education. Active partner relationship between students and teachers is adjusted to the characteristics and needs of each student, with clearly defined educational goals and responsibilities. Using appropriate resources, including state-of-the-art instruments, the Department takes care to maintain the quality of scientific work and study programs at the highest possible level.

DESCRIPTION OF THE DEPARTMENT The Department employs 43 teachers (of which 5 academicians and 3 professors emeriti), 24 junior researchers and 37 staff associates in five divisions. The average number of students is 500 in 4 different study programs (undergraduate chemistry studies, graduate chemistry studies, integral biology and chemistry studies, and integral physics and chemistry studies) and about 150 doctoral students in chemistry. There are two large lecture halls (with 150 seats each), several smaller seminar rooms, two computer rooms and different student laboratories.

CENTRAL CHEMICAL LIBRARY Central Chemical Library is one of the largest chemistry libraries in Croatia. It was formed by integrating the holdings of the libraries of the Institute for Physical Chemistry and the Croatian Chemical Society, so parts of library holdings have continuity since 1868. When the library was moved to the new Department of Chemistry building in 2005, its holdings were merged and now cover the fields of chemistry, partly mathematics, physics, biology, chemical engineering and technology and related sciences.

Horvatovac 102a
 HR-10000 Zagreb, Croatia
 Tel: +385-1-4606 000
<http://www.pmf.unizg.hr/chem>



Department of Chemistry – scientific activities

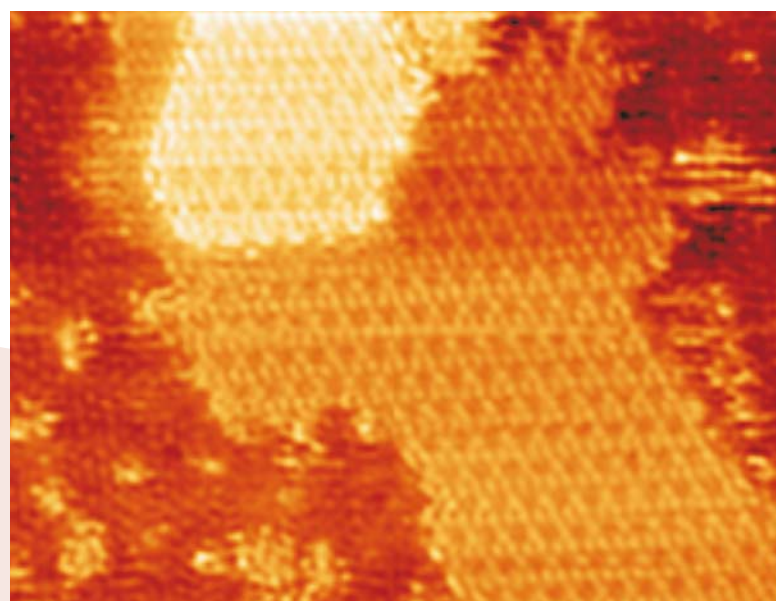
DIVISION OF GENERAL AND INORGANIC CHEMISTRY

Several groups carry out research in different spheres of chemistry: synthesis and characterization (including X-ray crystal structure analysis) of organic, inorganic and coordination compounds, solid state chemistry, supramolecular chemistry; structural characterization of proteins and other biologically active compounds. Classical chemical synthesis, but also modern methods like grinding, solvothermal, electroanalytical, microwave and ultrasound are applied to prepare organic, inorganic and complex compounds. Most of the prepared organic compounds are used as ligands in the synthesis of coordination compounds with metals (e.g. V, Cr, Mo, W, Co, Ni, Cu, Ag, Zn, Cd, Hg...), including polyoxometalate species. Crystal structures of these compounds contribute to our knowledge on the nature of bonds between metal atoms and ligands with oxygen, nitrogen, sulphur donor atoms, and on the mechanisms of homogeneous and heterogeneous catalysis and biological activity of transition metal complexes. Solid state chemistry involves investigation of the influence of non-covalent intermolecular interactions (hydrogen and halogen bonds, p-p interactions and van der Waals forces) upon molecular recognition and the structure and properties of molecular solids. Development of methods of supramolecular synthesis enables insights into the crystal structure of mono- or polycomponent systems, cocrystallization and polymorphism. Knowledge gained by such research is of great importance to pharmaceutical industry, environmental protection, nanotechnology and to materials chemistry in general. By solving the crystal structure of proteins and other biologically active compounds their biological functions and mechanisms of action can be deduced. Methods applied in these research areas include thermoanalytical methods (TG, DTA, DSC), IR, UV-Vis spectrometry, NMR, X-ray structural analysis on single-crystal

and polycrystalline samples, magnetic measurements. Several members of the Division are also devoted to the methodology of chemistry teaching and are dedicated to the chemistry teacher's pre-service and in-service training.

DIVISION OF PHYSICAL CHEMISTRY

Scientific work of the Division is an inseparable part of the teaching process and includes research in the fields of theoretical chemistry, thermodynamics, chemical kinetics, electrochemistry, colloid and interface chemistry, macromolecular chemistry, atmospheric chemistry, chemometrics and education. In theoretical chemistry, quantum-chemical methods are used to calculate potential energy and dipole moment surfaces, which enable highly accurate calculation of spectroscopic properties and determination of reaction mechanisms. Thermodynamic investigations involve equilibria of ion-association and complexation reactions in solutions and on the surface. Structures of complexes and relevant thermodynamic parameters are determined. Parallel kinetic investigations



provide an insight into the reaction mechanisms. Electrodes for electrochemical measurements are being developed. Colloid and interface chemistry investigations deal with the development of theoretical models and experimental techniques. Aggregation, adsorption, solid/liquid interface and surfactants are studied. In the field of physical chemistry of macromolecules, properties of polyelectrolytes and proteins in solution are studied as well as their adsorption on solid substrates. Polyelectrolyte multilayers and the conditions for their formation are investigated. Atmospheric processes are studied by physicochemical methods. Chemometric methods are developed and applied to interpretation and reduction of complex experimental data. Modern computer methods, chemometrics, spectrometry, (micro)calorimetry, stopped-flow spectroscopy, potentiometry, conductometry, optical reflectometry, electrokinetics and acoustophoresis are used in the research activities. Scientific work in chemical education is dedicated to developing a quantitative approach to chemical problems, based on clearly defined notions and their interrelations.

DIVISION OF ANALYTICAL CHEMISTRY

Investigations in the Division of analytical chemistry are carried out within several research projects. Surface-enhanced Raman spectroscopy is applied to study interactions and binding modes of biologically active small molecules with nucleic acids as well as to investigate adsorption mechanisms of the studied molecules on the nanoparticles in colloidal suspensions of silver and gold. Methods of vibrational spectroscopy (infrared spectroscopy, Raman spectroscopy) are used to study molecular structures of various organic compounds able to exist in different tautomeric and isomeric forms in aqueous and organic media. In-line Raman spectroscopy is being used for the real-time in situ monitoring of chemical and physical processes, e. g. chemical reactions and crystallization. UV-Vis spectrometry is used for determination of equilibrium constants of different compounds in solution. New methods are being developed for extraction and/or spectrophotometric and spectrofluorimetric determination of analytes based on interactions of metal ions and commercial or newly synthesized ligands. Conformational and structural analyses are carried out on the bioactive molecules



Photo: Danilo Balaban



of macrolides, thiosemicarbazones, carbohydrazones and their metal complexes using experimental (nuclear magnetic resonance, crystallographics, infrared and Raman spectroscopy, mass spectrometry) and computational methods (molecular mechanics and dynamics, ab initio methods). Results are correlated with biological tests to determine the structure-activity relationships. Interactions between the ligand molecule and biomacromolecules (ribosome) and the hydrogen bond, as an important factor of total structure and biological activity, are studied. Inductively coupled plasma atomic emission spectrometry (ICP-AES) is used for the determination of minor and major elements in fruits (e.g. apples, berries) and edible oils. Different samples (food, pharmaceutical products etc.) are analyzed qualitatively and quantitatively by high performance liquid chromatography (HPLC).

DIVISION OF ORGANIC CHEMISTRY

Scientific research is carried out as part of several projects covering different branches of organic chemistry. Classical and biocatalytic methods of organic synthesis are applied to synthesize new compounds containing monosaccharides (e.g. mannose, galactose) for which there are



Snimio: Danilo Balaban

receptors on cell membranes of living organisms. Among the prepared compounds are glycoconjugates of 1-adamantine, the well-known antiviral agent and drug for Parkinson's disease treatment; mannosyl adamantile tripeptide derivatives which possess antiviral and immunomodulatory activity; derivatives of peptidoglycan, an immunomodulator and antitumor and antimetastatic agent; glycoconjugates of different heterocyclic compounds, potential antidotes to organophosphorus compounds, etc. Mechanisms of solid state reactions are studied on a model system of aromatic nitroso monomer-dimers (azodioxide). The possibility of using such dimerizations as reactions through which nitroso compounds could be used as building blocks in supramolecular chemistry, or as molecular systems for formation of new intelligent materials is investigated. Their oligomerization is also studied, starting from self-assembly monolayers (SAM). Within the computational chemistry project, modern molecular modelling methods are applied to study the reaction mechanisms of different organic compounds, focusing on the structure and properties of participating reactive species. Special attention is paid to the role of solvents for the course and rate of reactions. Mechanisms of action of some metals and their complexes, as catalysts in organic reactions, are also studied, but to a smaller extent.

DIVISION OF BIOCHEMISTRY Within several ongoing projects, the structure, function and interactions of proteins and nucleic acids involved in genetic message translation are investigated. Aminoacyl-tRNA-synthetase enzymes that catalyze esterification of transfer RNA with cognate amino acids are studied. This reaction takes place in the cells of all organisms and enables protein biosynthesis. Modified forms of enzymes and other proteins are produced using genetic engineering methods. Conclusions on enzyme activity are made on the basis of kinetic parameters of biochemical reactions, determination of substrate binding constants, and by studying inhibitor action. Biological relevance of induced changes is checked by in vivo genetic methods. Collaborating with crystallographers, spatial structures of synthetases and their complexes with small molecules and macromolecules are determined and analyzed. The goal is to clarify the key role of aminoacyl-tRNA-synthetases in protein biosynthesis, their substrate specificity, mechanisms of hydrolytic correction of aminoacylation errors, and interactions with other proteins. Besides the fundamental importance of these investigations for explanation of protein synthesis as a basic biological process, the topic is interesting also from the pharmacological aspect.

Department of Chemistry – teaching activities

CHEMISTRY TODAY As one of fundamental natural sciences, chemistry is taught already in elementary school. It is the basis for understanding the molecular-level processes in both animate and inanimate world. As processes that take place in the environment are largely of chemical nature, knowledge of chemistry is necessary and will continue to be so in the future. Knowledge of chemistry is needed for fabrication of almost all objects surrounding us, so chemistry is a natural science that traditionally has its accompanying industry. Technology and quality control of most industrial products are based on knowledge of chemistry, and chemistry

is also important in energy production, both from the aspect of production and of its environmental impact.

UNDERGRADUATE STUDIES IN CHEMISTRY The course of chemistry studies lasts three years, in which students have to earn at least 180 ECTS points. Upon completion of this study program, holders of bachelor's degree (baccalaureus) satisfy the admission requirements for graduate chemistry studies at the Department of Chemistry, Faculty of Science. Acquired knowledge and skills qualify the students to participate in highly professional work, that is, to continue research or educational studies largely based on chemistry (graduate studies in chemistry, chemical engineering, pharmacy, biochemistry, molecular biology and environmental science). Admission conditions for university or professional degree programs at other higher education institutions are prescribed by those institutions. The academic title acquired upon completion of studies is Bachelor of Science in Chemistry (B. Sc.).

GRADUATE STUDIES IN CHEMISTRY

Research program The study course lasts two years, in which students have to earn at least 120 ECTS points. The program is a natural sequel to undergraduate chemistry studies at the Department of Chemistry, Faculty of Science, and is also open to students of related disciplines. Acquired knowledge and skills qualify the students for scientific-research work in chemistry and are a basis for scientific postgraduate studies in chemistry leading to doctorates in natural sciences. The study course is organized so that students can choose two out of five branches of chemistry (analytical, inorganic, physical, organic chemistry and biochemistry). Within the chosen specialty, students have to take some mandatory and some elective courses. In addition, another 6 elective courses have to be passed. These need not be in the chosen branches of chemistry. The academic title acquired upon completion of studies is Master of Science in Chemistry (M. Sc.).

Educational program The study course lasts two years, in which students have to earn at least 120 ECTS points.

The program is a natural sequel to undergraduate chemistry studies at the Department of Chemistry, Faculty of Science, and is also open to students of related disciplines. Acquired knowledge and skills qualify the students to teach chemistry at elementary and secondary schools (grammar schools) as well as technical schools where chemistry is taught. The academic title acquired upon completion of studies is Master of Education in Chemistry (M. Ed.).

Joint Studies In conjunction with the Departments of Biology and Physics, the Department of Chemistry organizes integral five-year educational courses of study in biology and chemistry and in physics and chemistry. Students have to earn at least 300 ECTS points during the course of studies, half of which have to be earned by passing exams in courses taught at the Department of Chemistry. Acquired knowledge and skills qualify the students to teach the two subjects (biology and chemistry or physics and chemistry), so it is easy for them to find employment at elementary or secondary schools. The academic title acquired



upon completion of studies is Master of Education in Biology and Chemistry (M. Ed.) or Master of Education in Physics and Chemistry (M. Ed.)

FOR STUDENTS OF OTHER DEPARTMENTS Knowledge of chemistry and chemical laws is also necessary to other natural science professions. Department of Chemistry offers instruction to students of other Faculty of Science departments (Mathematics, Physics, Biology, Geophysics and Geology). In addition to mandatory chemical subjects, students can choose among a number of courses according to their interests and needs of their basic discipline.

DOCTORAL STUDIES Doctoral studies in chemistry provide candidates with the knowledge of research methods and train them for independent scientific work. Doctoral studies are of at least three-year duration, with an average requirement of 60 ECTS points per year. Doctoral studies are a natural sequel to graduate chemistry studies (research specialty) at the Department of Chemistry, Faculty of Science, and are also open to students of related disciplines. The study course qualifies the students for independent research work in chemistry and related disciplines. The doctoral study course in chemistry is based on research work in adequately equipped laboratories within workgroups, helped by experienced supervisors, and on instruction through lectures, seminars and tutorials. The role of instruction is to

Department of Biology

on chemistry studies. This event has been organized since 2008 (pictures are from the University of Zagreb archives).

MAGIC CHEMISTRY Since 2007, the Department of Chemistry has been staging the event Witchcraft in Chemistry. Popular-scientific experiments are performed for pre-school and elementary-school children. Experiments are educative, visually attractive, but harmless. Their purpose is to attract children's attention, stimulate their interest in chemistry and demystify it. Witchcraft in Chemistry is preformed by a wizard and his assistants, with children's active participation.

PUBLISHING ACTIVITY Besides common publishing activity, which includes course materials such as university textbooks, technical books, mimeographed course materials and multimedial presentations, the Department of Chemistry also acts as co-publisher of the internationally recognized journal *Croatica Chemica Acta*, which brings articles from all branches of chemistry. The journal has been published since 1927 and its editorial office is located in the Department of

extend and deepen candidates' knowledge of related fields (along with the field of doctoral research). Of special value are advisory tutorials in small groups. Instruction is in principle elective; with coursed divided in three categories: general, basic and special. General courses Chemistry Seminar I, Chemistry Seminar II and Research Work are compulsory for doctoral students of all specialties (Inorganic and Structural Chemistry, Analytical Chemistry, Physical Chemistry, Organic Chemistry or Biochemistry). Basic courses cover the main disciplines within a specialty while special courses complement them. Doctoral studies end with the defence of doctoral theses within one of the scientific projects of the Department of Chemistry or other collaborative scientific institutions. The academic title acquired upon completion of doctoral studies is Doctor of Natural Sciences, field: chemistry [Doctor scientiarum naturalium ad chemiam pertinentium, Dr. Sc.].

Department of Chemistry – other activities

DEPARTMENT OF CHEMISTRY MEDAL

Since 2005, the Department of Chemistry has been awarding the Department of Chemistry Medal to its best students and deserving members of the Department. The medal features the first chemistry building of the University of Zagreb at Strossmayer's Square. The recipient's name is engraved on the reverse, which also bears the motto *Vivit post funera virtus*, freely translated as *Virtue is eternal*.

OPEN DAY OF THE DEPARTMENT OF CHEMISTRY

The Department of Chemistry Open Day is intended for all those interested in chemistry, particularly final-grade grammar and secondary school pupils who are thinking of choosing chemistry as their future vocation. Pupils can choose among interesting popular lectures, attractive and interactive workshops, touring scientific-research laboratories and a student roundtable where faculty students air their views



Photo: Patrik Macek

Chemistry building. The Department regularly issues its annual Report (since 1989). The report comprises the main information about the Department, a list of all its graduates with titles of their degree theses, as well as a list of scientific papers published by the Department members in that year. Also, since 2003, the Department has been preparing and printing the Periodic Table of the Elements with basic natural constants, which are regularly updated. The Periodic Table of the Elements is distributed free of charge at all manifestations in which Department members take part. It is printed in several thousand copies each year.



ORGANIZATIONAL STRUCTURE

Division of Zoology
Division of Molecular Biology
Division of Microbiology
Division of Botany and the Botanical Garden
Division of Animal Physiology

MISSION The curricula of the Department of Biology promote higher education in the scientific, experimental and educational areas of the biological sciences. Our students are prepared for employment and continued development in the field with a broad background of knowledge and skills. Course activities include lectures, exercises, seminars, field studies, methodological training, consultations, and international student exchanges.

VISION The Department of Biology strives to remain the central place for higher education and scientific and applied research in the field of biology. Resolving biological issues has awakened the interest not only of biologists, but also of natural historians, mathematicians, information scientists and other experts. It is precisely this interdisciplinary approach that has revealed explanations for many secrets of the living world, while many new, exciting and challenging questions are posed. The interactive relations between teacher and student in the study programme of the Department of Biology have set a high standard, with clearly defined educational objectives.

DESCRIPTION OF THE DEPARTMENT The Department staff includes 54 lecturers, 63 junior researchers and 9 staff scientists working in five divisions. Each year, around 1000 students are enrolled in the Integrated Undergraduate/Graduate Programme (Educational Degree in Biology and Chemistry), three Undergraduate Programmes (Biology, Molecular Biology, and Environmental Science) or four Masters Study Programmes (Experimental Biology, Ecology and Nature Conservation, Molecular Biology, and Environmental Science). Lessons are taught in six lecture halls, fourteen laboratories and two computer labs. The Department of Biology also includes the Biology Teaching Methods Unit, the Health and Physical Education Unit and the Central Biology Library.

CENTRAL BIOLOGY LIBRARY The five divisional libraries were merged to create the Central Biology Library. Most notably, the libraries of the Division of Botany and Division of Zoology were established in 1874 at the time of founding of the University. The library collection encompasses all areas of biology and several other fields of the natural sciences.

Rooseveltovej 6
HR-10000 Zagreb, Croatia
Tel: +385-1-4877 700
<http://www.pmf.unizg.hr/biol>

Department of Biology – scientific activities

Research in the Department of Biology

Research is conducted in 20 various thematic groups across all departments of the Department of Biology. The complexity and diversity of life is investigated at the molecular and cellular levels (molecular biology, genetics, immunology, virology, cell biology), at the level of organisms, from microorganisms to plants and animals (botany, zoology, marine biology, microbiology), and at the population and community levels (plant and animal ecology, including both laboratory and field studies). The objective of these studies is to uncover new scientific knowledge, which can serve as the basis for the development of technology and social advancement. The Department of Biology is also the home of the international scientific journal *Acta Botanica Croatica*.

Division of Zoology

Today, Division of Zoology strives to promote the study of basic and applied aspects of Zoology through teaching and research. Research is focused on the several main topics: fundamental and applied limnology, ecotoxicology, phylogeography, ecology and evolution.

Fundamental and applied limnology covers the biological, chemical, physical, and geological properties of all inland fresh waters (running and standing waters, natural or man-made). The fundamental researches include faunistic, taxonomic, ecological features of the protists, arthropods, molluscs and vertebrates. Applied researches are focused on biological water assessment and implementation of the composition of aquatic fauna in evaluation of environment: developing lists of indicators for different types of habitats and the establishment of monitoring surveys.

Ecotoxicological studies aim at improving environmental risk assessment and are mainly focused on the effects of environmental contaminants on cellular and genetic structure of aquatic or soil organisms. Several methods are applied for the evaluation of DNA damage and genome variability: Comet



assay and micronucleus test, AFLP method, mitochondrial DNA sequencing, microsatellite analysis and analysis of methylation status. Histological, histochemical and morphometrical methods are also applied to detect histopathological changes, as well as changes in enzyme activity, in different animal tissues and organs, such as gills, liver, intestine, kidney and gonads. Analyses are carried out in vivo and in vitro using a variety of model organisms (mainly cnidarians, planarians, mollusks, crayfish, fish and earthworms).

Phylogeographic research is directed on the study of the historical processes that may be responsible for the contemporary geographic distributions of individuals in light of the patterns associated with a gene genealogy. The subjects of these investigations are mostly aquatic organisms spread in the Dinaric karst of the Balkan Peninsula. The studies of different groups of animals show that these areas are regions from which the re-colonisation of northern Europe started in post-glacial period as well as pathways and directions of immigration and the area of Dinaric karst is probably centre of speciation for some freshwater invertebrate species.

Present ecological research includes a mixture of laboratory and field-based studies and it addresses both fundamental questions, as well as important issues in diversity and conservation. The research involves a wide range of organisms: invertebrates and vertebrates, epigeal, hypogean freshwater, marine and terrestrial species. It spans areas of basic and applied ecology, ranging from individual and population to community level studies. A part of the research is also directed to obtain new knowledge about reproductive biology and functioning of marine species, especially threatened, as well as their habitats, important for conservation in Croatia and in EU (NATURA 2000 species and habitats).

Current evolutionary biology research uses field and laboratory studies, experimental evolution and genome analyses on a range of organisms. Of special interest are molecular phylogeny, evolution and symbiosis of freshwater invertebrates, with an intention to provide clear insight into the significance of symbiogenesis in speciation process. It aspires to determine

taxonomic status of newly described taxa, the revision of known relict species and subspecies of freshwater invertebrates from Croatia, to determine divergence time and mechanisms of symbiosis in freshwater invertebrates (cnidarians/Hydra and its endosymbionts).

The Division houses a library and an impressive collection of zoological mounts. It cooperates with many domestic and international institutions.

Division of Botany, with the Botanical Garden

The Division of Botany and the Botanical Garden operates as an inseparable entity within the Department of Biology. The Division of Botany is located at three locations which are the centres of activity for high profile scientific research groups (ecology, vegetation, geobotany, floristics, archaeobotany, plant morphology, anatomy, flora, systematics, phylogeny, phylogeography, phytochemistry, palynology, horticulture, plant physiology, marine phytoplankton and fresh water algae). These research groups have collaborations, projects and other kinds of co-operations with eminent scientists and laboratories from all around the world. Research topics of the Division of Botany are numerous, organized throughout mentioned smaller research groups, which are able to perform all modern research techniques (e.g. light and electron microscopy in a variety of studies, GIS, sophisticated statistical analyses, numerous molecular methods (AFLP, DNA sequencing, microsatellite analysis, real time PCR etc.), in vitro cultivation of plants, chemical analyses (HPLC, spectroscopic methods) of bioactive plant compounds as well as analyses of their biological activities, palynological analyses etc.). Researches of diversity and ecology of marine phytoplankton of the Adriatic Sea, fresh water algae, flora, vegetation and habitats have also a prominent place in the expert and scientific activities of the Division of Botany. The direct product of research of diversity of plants is one of the best plant databases in the world - Flora Croatica Database (<http://hirc.botanic.hr/fcd/>), which exists since 1993. Our scientists, in collaboration with colleagues from other Croatian and foreign institutions, also perform applied botanical researches, such as the application of bioactive plant compounds in medicine, agronomy and biotechnology, plant ecotoxicological studies of influence of different pollutants, archaeobotanical studies from archaeological sites, aerobiological researches of pollen allergenes and allergophytes important for public health and tourism, other palynological researches (e.g. pollen in honey) etc. The Botanical Garden was established in 1889 and has a leading role in plant conservation, popularization of nature protection and education. The living plants collection keeps an invaluable treasure of Croatian indigenous flora, which constantly grows and is enriched through ex-situ conservation of protected, rare and endemic plant species. The Garden collection curators are engaged in a wide range of activities: from supervising plant cultivation and collecting living plants in the field through support in teaching various botanical courses. They are also involved in scientific and expert projects. Two important scientific Herbarium collections („Herbarium Croaticum“ and „Ivo and Marija Horvat“) are integral parts of the Department of Biology at the Faculty of Science. (<http://sciweb.nybg.org/science2/IndexHerbariorum.asp>). The “Herbarium Croaticum”

was founded in 1880 and has approximately 280,000 plant samples from Croatia and the rest of the world. The „Ivo and Marija Horvat“ herbarium collection was founded in 1918 and consists of around 80,000 plants vascular plants of South-eastern Europe.

Division of Animal Physiology

The Department was established in 1963 by Dr. Borislav Nakić, starting with courses in animal physiology and related subjects, and was aimed at introducing scientific studies in the field of animal physiology and immunology. Scientific work in the Department was initially focused on the area of transplant immunology. Today, the scientific and teaching staff of the Department conduct research in the fields of neurophysiology, biological therapy of tumours and metastases, conservation genetics and animal behaviour. In addition to the equipment necessary for teaching and conducting research, the Department also houses the animal facility for breeding laboratory mice and rats. A small area of the facility has been adapted for breeding reptiles and other small vertebrates.

Division of Molecular Biology

The Department of Molecular Biology was established in 1989 with the aim of advancing biological research at the molecular level and establishing a study curriculum in molecular biology. In the spring of 2004, the Department moved into its new premises, which provide excellent conditions for research and laboratory teaching. Research in the Department comprises of around ten scientific research projects funded by the Ministry of Science, Education and Sport of the Republic of Croatia. Several researchers also participate in prestigious internationally funded research projects. Molecular biology research is carried out on both plant and animal models, with research topics ranging from developmental biology, genomics and biomedicine to proteomics, computational biology and bioinformatics. The Department houses the core microscope facility including electron microscope, laser microdissector with micromanipulator and fluorescence microscopes. In the field of plant and animal biology, there are four main areas of research. 1) Studying the structure, organisation and evolution of the genome at the chromosomal and molecular levels. 2) Research in the area of developmental biology and regulation of secondary metabolism is directed at the identification and functional characterisation of genes associated with embryogenic plant development, and at determining the regulation and biosynthesis mechanisms of phenolic secondary metabolites. 3) Research of chromatin dynamics and gene plasticity relates to the analysis of epigenetic modifications that alter the structure and function of individual genomic areas, alterations in the methylation status of certain genome areas that cause the formation of epialleles (rDNA epialleles) and three-dimensional organisation of active and inactive rDNA chromatin within the interphase nucleus. 4) Research of plant proteomes is aimed at obtaining a better understanding of the development processes in plants, and of plant responses to abiotic stress. Biological systems established by tissue and cell cultures have been used as starting material for cell fractioning, protein extraction and quantification of enzymes and secondary metabolites. In the field of toxicology, research is focused on the extent to which stress caused by heavy metals and model genotoxics,

as well as abiotic stress damage on the DNA molecule, cause its epigenetic modification (changes in methylation patterns) thus impacting mechanisms of gene expression regulation. Analysis of biochemical parameters (lipid peroxidation, oxidative damage of proteins, activation of antioxidant systems) is employed to investigate the links between oxidative damage to plants and the quantity of heavy metals accumulated over a given time period. Research is also conducted in three areas in the field of biomedicine. 1) Investigating the influence of ultraviolet radiation on the DNA molecule and guidance of the cell in programmed cell death (apoptosis); apoptotic pathways induced by UV radiation and the impacts on important physiological functions using the FADD cell knockout model, and in particular, studying the relationship between the membrane and mitochondrial mechanisms of apoptotic signalling pathways. 2) Research on the regulation of cell proliferation and cell death in chronic myeloproliferative diseases is investigated by analysing the expression and activity of proteins in colonies of progenitor cells in the bone marrow of affected patients. 3) Investigation of the role of poly(ADP-ribosylation), as a post-translational protein modification in the response of animal cells to damages and in tumour-generating processes.

The research in the field of bacterial genetics is focused on exploring the defense mechanisms of bacteria from foreign genetic elements. Two mechanisms are investigated: (I) incorporation of short DNA fragments from viruses or plasmids into CRISPR loci that are suggested to provide the „genetic memory” that will protect the new host from infection with the same virus and (II) modification system in which the host DNA is protected from the invasion of foreign DNA by methylation modification.

In the fields of bioinformatics and computational biology, information technology methods, machine learning and statistics are applied on high-throughput experimental data in several projects aimed at discovering the fundamental principles of life at the genomic level. 1) Metagenomics is the analysis of vast quantities of genomic data obtained by DNA sequencing samples taken directly from microbial environments, for the purpose of investigating genetic diversity, adaptation and evolution of genetic information at the level of entire ecosystems. 2) Development of programming tools for the analysis, display and contextual integration of data obtained from microarray (or similar genomic) experiments. 3) Application of machine learning methods in predicting epigenetic signals in the regulation of eukaryotic transcription (in cooperation with the Max Planck Institute for Molecular Genetics in Berlin, Germany). 4) Development and experimental verification of predictive models for exonic splicing enhancers, in cooperation with the International Centre for Genetic Engineering and Biotechnology (ICGEB) in Trieste, Italy. 5) Computer predictions of protein interaction sites directly from primary sequence, without the need for structural data. 6) Classification of protein folding patterns using statistical and machine learning methods.

Division of Microbiology The Department of Microbiology was established in 2010. It is housed at two locations: 9A Marulić Square and at 6 Roosevelt Square. The research at the Department comprises scientific projects funded by the Ministry of Science, Education and Sports of the Republic of Croatia and internationally funded research

projects. The research of the Department of Microbiology encompasses: (I) monitoring, detection, characterization, genetic diversity and variability of plant, animal and human pathogens: fungi, cultivable bacteria and phytoplasmas, viruses and subviral agents (viroids and satellites) of particular interest in agronomy, forestry, health care and waste water treatment, (II) the use of bioactive substances in treatment of pathogens and the use of viruses in biological control of pathogens, (III) molecular interactions of pathogens and their hosts. The group has a strong background in molecular biology and application of techniques like PCR, real-time PCR, SSCP, LAMP, HPLC separation of viruses and nucleic acids of different origin, genetic transformation of plants and bacteria, cloning, genotyping by using MLST analysis, phylogenetic analyses and annotation of genomes. Tissue culture of different plant species is used for maintaining plant pathogens and extraction of bioactive substances. Cultures of fungi, bacteria and plants are used for testing antipathogenic activity of bioactive substances. The Department also has a strong background in microbial ecology and application of techniques like isolation and cultivation of physiological groups of bacteria, human and animal pathogenic bacteria, indicators of faecal contamination, immobilization of bacteria onto different materials and chemical analysis of water. In the own bank of bacteria, 50 human bacterial species are maintained. The Department also houses a collection of phytoplasmas, plant viruses and viroids. The present activities are oriented towards basic and applicative research and teaching but also cooperation and transfer of know-how to agronomy, forestry, environment management and health care.

Department of Biology – teaching activities

Biology today We live in the age of the most exciting biological discoveries Ð on a daily basis we are learning something new about the structure and function of living systems. From a primarily descriptive science biology has evolved into an exact natural science investigating both living creatures in their natural habitats, and planning and implementing laboratory experiments to study various models of life. Stemming from the individual as an entity and the cell as the fundamental unit of life, biologists work together with other natural scientists to discover the molecular and subcellular foundations of life. They are revealing the secrets of heredity and the complex processes that make it possible for the genetic code to create some of the many exceptionally diverse forms of life on Earth. Biologists also research highly complex systems, such as organisms, populations and biocenoses of ecosystems. They are interested in learning how living creatures adapt to environmental conditions, their behaviour and evolution from common ancestors.

Integral undergraduate/masters programme in biology and chemistry education This five-year programme is lecture based. A minimum of 30 ECTS must be registered in each semester, with a total of 60 ECTS points per year, selected among the mandatory and elective courses. Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses

from other university study programmes. Courses are held by the Department of Biology and Department of Chemistry staff. The academic title earned upon the completion of study is Master of Education in Biology and Chemistry (mag. educ. biol. et chem.).

Undergraduate programme in biology This is a three-year study programme. Following the successful completion of this study programme, the bachelor student has the possibility of enrolling in one of the masters programmes in the Department of Biology. A minimum of 30 ECTS points must be registered in each semester, for a total of 60 points per year from the groups of mandatory and elective courses. Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses from other university study programmes. The academic title earned upon the completion of study is university baccalaureate of biology (univ. bacc. biol.).

Masters programme in experimental biology This is a two-year study programme. A minimum of 30 ECTS points must be registered in each semester, for a total of 60 points per year from the group of mandatory and elective courses from one of the three offered modules (Physiology and Immunobiology, Botany or Zoology). Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses from other university study programmes. A graduate thesis also needs to be prepared within one of the three offered modules. The academic title earned upon the completion of study is master of experimental biology (mag. biol. exp.).

Masters programme in ecology and nature protection This is a two-year study programme. A minimum of 30 ECTS points must be registered in each semester, for a total of 60 points per year from the group of mandatory and elective courses from one of the three offered modules (Terrestrial, Freshwater and Marine). Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses from other university study programmes. A graduate thesis also needs to be prepared within one of the three offered modules. The academic title earned upon the completion of study is master of ecology and nature protection (mag. oecol. et prot. nat.).

Undergraduate programme in molecular biology This is a three-year study programme. Following the successful completion of this study programme, the bachelor student has the possibility of enrolling in one of the masters programmes in the Department of Biology. A minimum of 30 ECTS points must be registered in each semester, for a total of 60 points per year from the groups of mandatory and elective courses. Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses from other university study programmes. The academic title earned upon the completion of study is university baccalaureate of molecular biology (univ. bacc. biol. mol.).

Masters programme in molecular biology This is a two-year study programme. A minimum of 30 ECTS points must be registered in each semester, for a total of 60

points per year from the group of mandatory and elective courses from one of the five offered modules (Genetics, Cell Biology, Human Biology, Computational Biology and Structural Biology). Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses from other university study programmes. A graduate thesis is also prepared within one of the five offered modules. The academic title earned upon the completion of study is master of molecular biology (mag. biol. mol.).

Undergraduate programme in environmental sciences This is a three-year study programme. Following the successful completion of this study programme, the bachelor student has the possibility of enrolling in one of the masters programmes in the Department of Biology. A minimum of 30 ECTS points must be registered in each semester, for a total of 60 points per year from the group of mandatory and elective courses. Elective courses available to students include those offered in all study programmes of the Department of Biology, and courses from other university study programmes. Courses are held by the Departments of Biology, Geology and Geography. The academic title earned upon the completion of study is university baccalaureate of environmental sciences (univ. bacc. oecol.).

Masters programme in environmental science This is a two-year study programme. A minimum of 30 ECTS points must be registered in each semester, for a total of 60 points per year from the group of mandatory and elective courses from one of the three offered modules (Biological Environmental Protection, Geographical Environmental Protection and Geological Environmental Protection). Elective courses available to students include those offered in all study programmes of the Departments of Biology, Geography and Geology, and courses from other university study programmes. A graduate thesis also needs to be prepared within one of the three offered modules. The academic title earned upon the completion of study is master of environmental science (mag. biol. oecol.).

Doctoral studies Upon completion of undergraduate and graduate studies, successful students can enrol in the three-year doctoral studies programme. Research in post-graduate studies is carried out within the framework of a scientific project or research topic under the mentorship of an experienced scientist. Doctoral candidates who publish scientific papers and who have successfully defended their doctoral dissertation acquire the title of Doctor of Natural Science, field Biology (Doctor scientiarum naturalium ad biologiam).

The post-graduate study programme requires acquiring 180 ECTS points (60 per year of study), of which a minimum of 38 and maximum of 52 ECTS points come from courses and the remaining points come from scientific activities that ultimately lead to the preparation of the doctoral dissertation. Upon enrolment of the first year of study, the student selects three courses from the list of standard elective courses (total of 24 ECTS points), depending on the interests and the branch of research the student intends to undertake. The student enrolls in Seminar I (20 ECTS points) which must be prepared and publicly presented during the first year. The remaining 16 ECTS points

Department of Geology

ORGANIZATIONAL STRUCTURE

Division of Geology and Paleontology
Division of Mineralogy and Petrography
Central Geological Library

MISSION The department of Geology provides high quality education for students on all levels as well as research in geosciences, specifically geology and its individual disciplines; physical geology, tectonics, paleontology, stratigraphy, mineralogy, petrology and geochemistry. Thus it contributes to the knowledge and understanding of geology and evolution of the European territory. Furthermore, our mission involves the development of teaching methodics and popularization of geology in the general public.

VISION Based on hundred-year old tradition, the Department develops modern geological research which is recognized as a contribution to the advancement of geosciences. The education of geology students actively follows new developments in science, integrating scientific research with the goal of increasing creative involvement of students in education and scientific research. The Department promotes the advancement of geology as a whole, to which the planned construction of our new building will greatly contribute, which will integrate all of our educational and research facilities.

DESCRIPTION OF THE DEPARTMENT The Department employs 20 full, associate and assistant professors, and 2 senior lecturers, in addition to 6 postdoctoral fellows and 8 doctoral students. The members of our Department are also two emeritus professors, two academicians, and two associates of the Croatian Academy of Sciences and Arts. Approximately 300 students study Geology, within 2 Undergraduate study programs; Bachelor of sciences in Geology, Bachelor of sciences in Environmental Sciences (in cooperation with the Departments of Biology and Geography), 3 Graduate study programs; Master of sciences in Geology, Master of sciences in Environmental Sciences (in cooperation with the Departments of Biology and Geography), and Master of sciences in Environmental Geology, and 2 Postgraduate programs; Doctoral study of Geology and Doctoral study of Oceanography (in cooperation with Departments of Biology, Geophysics, and Ruđer Bošković Institute).

Horvatovac 102a
HR-10000 Zagreb, Croatia
Tel: +385-1-4606 080
<http://www.pmf.unizg.hr/geol>

600 members, with presently more than 100 active members. Since its establishment, a series of significant events have been organized, such as the now traditional Biology Camps that regularly attract more than 60 students and mentors each year, and result in a series of scientific papers published as proceedings. Another important event is the European Biology Students Symposium held in Zagreb and Zadar under the auspices of the Croatian President. The association also organizes a series of research and educational events for inventorying species and habitats and environmental protection in cooperation with state institutions (ministries, institutes, national parks, etc.) and non-governmental organizations. The association publishes the magazine In Vivo, which started as just a few photocopied pages and grew into a full-colour 96 page magazine. BIUS maintains a website that strives to become the main source of information on events and projects in the field of biology and the study of biology in Croatia. Lectures, seminars, symposia and schools are organized to raise student interest for aspects of biology and life that are perhaps not best defined or



covered during the programme of study itself, but represent an integral part of students' future professions. Today, BIUS has a well defined organizational structure and technical support, from administration and finance to premises and equipment. Its administration has been organized with the help and cooperation of members of some of the best non-governmental organizations in Croatia. In addition to the above mentioned activities, members of BIUS also participate in the official activities of the Council of the Division of Biology, Council of the Faculty of Science and the Presidency of the Student Council of the Faculty of Science, thereby directly influencing events within the University of Zagreb and participating in the creation of teaching plans and programmes. Today, BIUS is an integral part of the study of biology at the University of Zagreb, and an unavoidable part of the Zagreb student's scene.

PROFESSIONAL SOCIETIES The Division of Biology is the host organization of the Croatian Biological Society 1885, Croatian Ecological Society, Croatian Society for Plant Biology, Croatian Botanical Society, Croatian Ichthyological Society and the Croatian Association of Genetic Engineers.

may be obtained in elective activities (participation in scientific meetings, workshops, scientific training, scientific production, participation in the teaching process, etc.). However, these are not conditional for enrolment into a higher year of study.

In the second year of study, the student enrolls in and completes elective courses in the field of research which is carried out as part of the preparation of the doctoral dissertation. The courses carry from 14 to 28 ECTS points. The student also enrolls in Seminar II from the topic of the doctoral dissertation, while the remaining points are obtained through elective activities.

In the third year of study, the student is required to earn 40 ECTS points for scientific research during the preparation of the doctoral dissertation, and the remaining points (up to a total of 180 for the entire course of study) from elective activities.

Department of Biology – other activities

NIGHT OF BIOLOGY Department of Biology organized the first Night of Biology in 2009. The idea behind the event is to popularize the biological sciences, and for the first time ever the Department opened the doors of its laboratories in the late afternoon and evening hours to the general public of all ages, including schoolchildren and future students. This event is a new, popular way to bring the research within the Department closer to the public. Simple and interesting experiments, short presentations and workshops were presented to help visitors experience science and biology.

BIUS – BIOLOGY STUDENTS ASSOCIATION In March 1999, the BIUS association was formed to meet student demands for a high quality, more productive and more entertaining study of biology. The founders, led by Sandra Dujmović, succeeded in establishing an association that is unquestionably one of the best and most affirmed student associations in the country. Over time, the association has grown on its foundations to include more than



Department of Geology – scientific activities

The Department of Geology comprises two Divisions, sometimes also called "institutes"; The Division of Geology and Paleontology, and the Division of Mineralogy and Petrography.

The Division of Geology and Paleontology is located in the new Building of Chemistry and Biology, where it operates on two floors. The Division is manned with 11 full, associate and assistant professors, and 1 senior lecturer, who are supported by technical and administrative staff of 6. The Division of Geology and Paleontology currently hosts 4 postgraduate fellows and 4 doctoral students working on the Division's research projects. The Division has Stratigraphic Collection hall which is being used by our students and researchers, with fossil and rock samples form all over the world, which also hosts micropaleontological collection with many type genera and species. The Division has also Geological and Paleontological Laboratory equipped with diamond saws and apparatus for preparation of thin-sections, wet sieving, and X-ray granulometry. There is also Electron microscope Laboratory with scanning electron microscope equipped with EDAX microprobe, and optical microscopy lab. The Division of Geology and Paleontology teaching facilities comprise a medium-size lecturing hall, geological mapping hall, seminar hall, laboratory for optical microscopy, and Stratigraphic Collection hall. We also take advantage of lecturing halls in the Chemistry building, particularly the informatical hall for the teaching of GIS and software in geology.

The Division of Mineralogy and Petrography is located on the top floor of the Geophysics Building. It is manned with 9 full, associate ad assistant professors and 1 senior lecturer, who are supported with technical and administrative staff of 6.

The Division of Mineralogy and Petrography currently hosts 2 postdoctoral fellows and 4 doctoral students working on the Division's research projects.

The Division has Mineralogical and Petrographical Laboratory equipped for chemical analyses, large diameter diamond saw

and apparatus for preparation of thin sections. There is also Laboratory for X-ray diffraction analysis equipped with modern instrumentation, a vintage scanning electron microscope, and the equipment for the study of fluid inclusions.

The Division has Mineralogical and Petrographical teaching facilities comprise two lecturing halls, a seminar room, and mineralogical and petrological collection rooms.

The Central Geological Library is located in the main Chemistry Building, where it shares the hall with the Central Chemical Library, while a part of the fundus covering mineralogy, petrology, and geochemistry is located in the Division of Mineralogy and Petrography premises.

The Library keeps scientific and educational publications; periodicals, textbooks, catalogues, geological and topographical maps, conference proceedings, Diploma and Master Thesis, and Doctoral Dissertations.

DIVISION OF GEOLOGY AND PALEONTOLOGY

The scientific research at the Division of Geology and Paleontology is conducted within several national and international research projects, whose object of research are coastal and internal Dinarides; specifically their structure, genesis, and evolution during the geological history. The research is conducted both in the field and laboratory, and comprises field mapping, biostratigraphical and paleontological analyses, sedimentological studies, as well as granulometric and microchemical studies. The research topics include:

The study of detrital sediments, which is aimed at reconstructing the evolution of the Dinaric mountain belt since the Jurassic. This evolution is being traced from a time when an oceanic domain existed on one side and a stabile carbonate platform on the other side, and afterwards through turbulent periods of compression and development of first early and subsequently younger structures of the Dinarides, up to the present time.

The study of stress events in the geological past, determining their causes and consequences by means of paleontological, sedimentological, geochemical, and isotope analyses. Palaeozoic strata and evidence of mass extinction

at the boundary between the Palaeozoic and Mesozoic era are being studied in the karst Dinarides. The changes in paleotemperatures, sedimentary environments and fossil content, as well as oil potential, are being traced within the clastic Miocene sediments of northern Croatia.

The study of breaks in sedimentation within the carbonate successions of the karst Dinarides. These breaks provide clear facies elements for the interpretation of environmental conditions at different periods of the geological past, and represent easily recognizable markers for the correlation of contemporaneous deposits, both at the surface and in boreholes. Their presence is also reflected in the economic aspect of the Dinaric area since they can represent horizons of subsurface channelling and/or blocking of fluid flows, such as hydrocarbons, hydrothermal and pore waters.

The study of shallow marine carbonate environments during Cretaceous and Palaeogene of the

years, proved the existence of an extensive ice-cover which extended well below the modern sea-level and far from the modern eastern Adriatic Sea coast.

The study of sedimentation pattern on continental shelf, sedimentation in river mouths, surface characteristics of suspended and sedimented mineral particles, the role of suspended particles in transport and fate of contaminants, study of drowned karst phenomena, and marine geological cartography.

DIVISION OF MINERALOGY AND PETROGRAPHY

The scientific research in the Division of Mineralogy and Petrography is conducted within several national and international research projects, and covers a wide spectrum of topics:

The analysis and determination of the crystal structure of natural and synthetic compounds by means of



Eastern Adriatic coast comprise analysis of sedimentary rocks, changes in fossil communities, and changes in living strategies of dominant specialised organisms. Special attention is given to the speed and manner of ecosystem rejuvenation following a biological crises (recolonization which was dominated by rudists in the Cretaceous, and large benthic foraminifera in the Palaeogene).

The study of effects of catastrophic events in the external Dinarides which had a substantial impact on Earth's climate the evolution of life and shaping of its surface comprises the study of impact structures and impact products, meteoritic materials, paleoseismic indicators as well as paleoclimate. A large impact structure on the island of Krk could have had an important impact on the climate on the Northern Hemisphere, as well as on the biological evolution, which makes the study of its age and chemistry essential. The chemical composition of microtectites and spherules from Eocene age clastic sediments indicates on yet unknown large terrestrial impact. The study of paleoclimate in Dinaric mountain range over the last 2 million

X-ray diffraction is one of primary research topics of the Division. It embraces the study of characteristics, genesis and stability of individual minerals and mineral groups with application to mineralogy and petrology, as well as to the systematics of the unknown minerals. A considerable part of the research is related to the determination of crystal morphology and crystallogenes, as well as the interpretation of the relationship between the crystal morphology and the physical and chemical conditions during crystallization, while an ever more important area of research is related to the impact of minerals and environment.

The study of possibilities of using certain minerals or mineral groups for the storage of various environmental contaminants is also one of prominent research topics.

The study of biomineralization and related research on tissue regeneration. It is complementary to the study of the interaction of living organisms and minerals, and biological



control of development of certain mineral phases in living organisms. The increasing attention is paid to the role of enzymes in the crystallization of minerals.

The study of diagenetic processes in sediments, with emphasis on zeolite genesis in pyroclastic rocks.

The study of sediments and sedimentary rocks includes the study of facies, sedimentary systems and sedimentary basins of different stratigraphic units in inner end external Dinarides. Special attention is given to petrofacies analysis, provenance analysis and interpretation of geotectonical history of the sources of the clastic material. Mineralogical and geochemical research provide valuable data on weathering processes and anthropogenic influence on sediments.

The study of magmatic rocks comprise the study of mafic and ultramafic rocks in Dinarides, as well as xenolites and accessory minerals in granites. Also, the genesis of magmatic and metamorphic series of the Pannonian basin and the Dinarides is being studied utilizing the mineral provenance and age data provided by the isotope analysis.

The study of metamorphic rocks comprises quantification of the metamorphic processes, P-T-t evolution of mineral associations, geochronology, and fluid-rock interaction at low temperatures between diagenesis and metamorphism.

Geochemical studies are receiving growing attention in environmental protection. Geochemistry of mineral deposits involves the study of stable and radiogenic isotopes, fluid inclusions, as well as geochemistry of trace elements, including rare earth elements. Research of ore deposits has involved all larger deposits of the Dinarides. Traditional microscopic and X-ray methods are accompanied by data from isotope geology (stable isotopes, S, O and C, K/Ar, Rb/Sr, Ar/Ar, U-Th-Pb), from organic geochemistry of oil and ore deposits, and the study of fluid inclusions in ore and gangue minerals.

The geochemical study of heavy metal distribution in environment, including soil, air, water and river sediments. The primary distribution due to geological

factors is complicated due to anthropogenic influence (industry, urbanization, wild landfills). Geochemistry of the environment is oriented towards landfills, anthropogenic influence and pollution caused by natural geochemical anomalies (rocks and ore).

The study of possibilities of removing harmful components from sewage waters by use of minerals, e.g. zeolites, and products of industrial processes, is a multidisciplinary research in cooperation with other natural sciences.

The study of artefacts in cooperation with archaeologists.

Department of Geology – teaching activities

Geology today The planet Earth is a dynamic system characterized by constant changes of its surface and crust, which necessitates its continuous study and novel interpretations. This makes geology one of most dynamic scientific disciplines. Geological research involves our entire planet, but it extends also to other terrestrial planets. Geology involves a very wide range of research, starting with fundamental research on the basic building blocks of our planet, minerals, through environments in which rocks form, to the evolution of life and interpretation of the past climates, all the way to the study of mineral resources, water, and processes which occur at the Earth surface, and cause changes in relief. Our research is often complementary with other natural sciences; therefore many common interests exist with biology, geophysics, geography and chemistry. Geology today involves the study of mineral structure, genesis of rocks, migration of chemical elements, migration pathways of contaminants, and genesis of mineral deposits. The research is conducted on movements of the Earth's crust, movements of magma and its cooling, the melting and transformation of rocks deep in the crust, the activity of volcanoes, as well as many other

processes and phenomena. Also studied are the structure, systematics and living habits of extinct animals and plants, the evolution of life on Earth, processes in today's and past seas, lakes, deserts and glaciers, on coasts and on the mountains, as well as changes and the disappearance of environments. Geology studies karst and its evolution, the flow and chemistry of underground and surface waters, the functioning of today's environments and effects of the human influence. Alongside traditional applications of geology in the acquisition of mineral resources, fresh and thermal water, the role of geology today is very important in assessing the impacts of various constructions on the environment, and solving problems of the sustainable development.

BACHELOR OF SCIENCE PROGRAM

Bachelor of science in Geology: 3 years duration.
Bachelor of science in Environmental Sciences: 3 years duration (in cooperation with Departments of Biology and Geography).
The prerequisites for enrolment in the B.Sc. program are

grammar school diploma and successful state matriculation. The B.Sc program lasts 6 semesters and incorporates both indoors teaching and fieldworks, in total of 180 ECTS. The students obtain basic knowledge on geological and related sciences, which is mostly provided by compulsory courses at the 1st year of study, courses and seminars in 2nd, and elective courses in 3rd.

After completing the program, the students obtain the title: Bachelor of Science in Geology, and Bachelor of Science in Environmental Sciences.

B.Sc. in Geology qualification entitles the holder to seek employment in geological research, but also qualifies them to continue their education at the Master of Sciences program in Geology (with two options to specialize: Geology and Paleontology, and Mineralogy and Petrology) or Environmental Geology. It is also possible to migrate to other disciplines in natural Sciences or Geological Engineering.

MASTER OF SCIENCE PROGRAM

Master of Science in Geology: 2 years duration, major: Geology and Paleontology, Mineralogy and Petrology.

Master of Science in Environmental Geology: 2 years duration. Bachelors of Science in Geology and Bachelors of Science in Environmental Geology can continue their education at the Graduate study in duration of 2 years (4 semesters), which are worth 120 ECTS. The study program incorporates compulsory and elective courses, seminars and fieldwork, with ample options to master a sub-discipline within two major profiles – Geology and Paleontology, and Mineralogy and Petrology. A supervisor is assigned to each student during the course of the study. Individual research in the final year of study leads a student to preparation of a diploma Thesis which is being defended in public final exam before the appointed committee. After successful completion of the study program, the students are awarded the title Master of Science in Geology or Master of Science in Environmental Geology.

The M.Sc. in Geology and M.Sc. in Environmental Geology qualifies the holder to work in geological and environmental research, environment protection, mineral resources industry, environmental agencies, consulting and services companies, civil engineering and construction companies, water resource management companies, ceramic industry, urban planning and natural hazard mitigation agencies, and state agencies for the management of protected areas.

Ambitious M.Sc. students can proceed with advanced study at the Postgraduate program of Doctoral study of Geology.

DOCTORAL STUDIES

M.Sc. holders with particular interest in science and above-average GPA achieved during the Graduate study, are entitled to proceed with their high education at the Doctoral study of Geology, or Interdisciplinary Doctoral study in Oceanology (joint studies of Faculty of Science, Division for Marine and Environmental Research (formerly Center for Marine Research, Zagreb) and Center for Marine research, Rovinj of the "Ruder Bošković" Institute in Zagreb and Institute for Oceanography and Fisheries in Split and Dubrovnik).

During the Postgraduate study, a student chooses elective courses from a wide list of offered advanced courses, shaping his or her individual study program. The study program



provides advanced theoretical knowledge, and training of advanced research methods and techniques. Doctoral students are appointed a supervisor who acts as a counsellor in charge, until the doctoral Thesis topics is approved and formal supervisor (mentor) appointed. The most important part of the program is mentored individual research on a research project, which leads to the preparation of a Doctoral Thesis which is being publicly defended before the committee appointed by the Faculty of Science. Upon successful defence of Doctoral Thesis candidates achieve the title Doctor of Science in the field of Geology and Doctor of Science in the field of Geosciences, Oceanology.

Department of Geology – other activities

PROFESSIONAL ASSOCIATIONS

Professors and young researchers of the Department of Geology are active members of many national and international professional associations and societies, such as Croatian Geological Society, ProGEO-Croatia, Croatian Union of Petroleum Engineers and Geologists, Croatian Natural Science Society, and specialised professional Committees of the Croatian Academy of Sciences and Arts. By involvement in society work, our participating staff contributes to dissemination of their knowledge and popularization of science. Some are involved in organization of science-popularization manifestations such as Science Festival, whereas some are actively cooperating with schools and public libraries providing public lectures and workshops.

SCIENTIFIC EXCURSIONS Department of Geology professors actively participate in organization and guidance of scientific excursions and field workshops throughout the Dinarides for foreign and domestic geologists. They are also authors of Guidebooks which are regularly being prepared for the excursions, often as a publication of scientific conferences. Our doctoral and graduate students are usually given chance to get involved in preparation and guidance of the excursion,

as an opportunity to expand their knowledge and gain the field experience.

GEOTRAILS The Department of Geology is involved in promotion of geology in the field, particularly in protected areas such as national parks, geoparks and natural reserves, where educational geo-trails are being designed and geological phenomena (fossils, minerals, rocks, geological structures) described on explanatory boards and in dedicated guidebooks.

SCIENCE FESTIVAL The annual Science Festival in Zagreb is being organized by several members of the Department of Geology who prepare public lectures, exhibitions, workshops, presentations and round tables. These activities serve as promotion of science, geology in particular.

INFORMING THE PUBLIC The general public is being informed about geology in various ways, though primarily by electronic media. Our professors and senior students are frequent guests in Croatian television educational programme, as well as Croatian radio programme. There they provide scientific accounts of some generally interesting topics (volcanoes, earthquakes, tsunamis, dinosaurs, etc.).

PUBLISHING ACTIVITY The Department of Geology publishes a periodical Bulletin to inform its faculty and students, as well as general public, about current activities and the department news. The themes range from educational issues, history of science, our scientific activity and the department life. Our professors are also editors of some professional and scientific journals, whereas some are translators of foreign textbooks and popular science books, which also serves in promotion of science.

Department of Geography

ORGANIZATIONAL STRUCTURE

Division of Human Geography

Division of Physical Geography

Division of Regional Geography and Teaching Methods

MISSION Department of Geography, Faculty of Science, enables university education and knowledge in many geographic fields by a series of study programmes. In scientific-research and teaching work it explains the patterns of spatial relations promoting an integral approach in the space comprehension. Department of Geography contributes to the development of the Croatian and world geography.

VISION Department of Geography is dedicated to accomplishing the highest standards in student education using modern methods and knowledge in the field of geography. The principal aim is to educate experts who will raise the work and research quality in education, economics and other segments of the society. By scientific-research work of the Department staff and students, as well as by the application of the existing and new methods, geography is planned to be included into all fields dealing with space research, valorisation, use and protection.

DESCRIPTION OF THE DEPARTMENT At the moment there are 18 teachers at three divisions of the Department of Geography (2 of them are professors emeriti), 1 senior lecturer, 5 junior researchers - senior assistants, 6 junior researchers and 3 technical assistants. There are around 400 students at the undergraduate and three graduate studies (professor of geography, professor of geography and history in collaboration with the Faculty of Humanities and Social Sciences, and master in geography). There are also common undergraduate and graduate studies of Environmental Sciences in collaboration with the Departments of Geology and Biology, Faculty of Science. About 52 students have enrolled in the postgraduate study. Lectures take place in one large lecture-room, several smaller seminar rooms and a computer room.

CENTRAL GEOGRAPHIC LIBRARY Central Geographic Library, Faculty of Science, was established in 1910. In 1927, it was divided into the Library of the Physical Geography Division and the Library of the Anthropogeography Division. The library was integrated again in 1946 and placed into its today's location. Till 1994, the Central Geographic Library was the only geographic library in Croatia. Its material covers the field of geography and related ones.

Marulićev trg 19/II
HR-10000 Zagreb, Croatia
Tel: +385-1-4895 400
<http://www.pmf.unizg.hr/geog>



Department of Geography – scientific activities

DIVISION OF HUMAN GEOGRAPHY

Scientific work in the Division of Human Geography deals with rural and karst areas, population and border regions. It proceeds through scientific projects financed by the Ministry of Science, Education and Sports. In the project Geographic Evaluation of Spatial Resources in Rural and Karst Areas of Croatia the earlier mono-sector approach to ruris, where agriculture was the basic development instrument, has been replaced by integral evaluation of all spatial resources in the framework of the sustainable development concept.

In that connection, the study focus was moved to a complex geographic area out of larger cities, with the aim of coordinated evaluation and protection of its environment. This research is a contribution to the improvement and revitalization of the parts in Croatia affected by rural retrogression. According to it, rural and karst areas are supposed to be evaluated and their environment protected. Such a development direction makes an imperative of the development in Croatia and a component of its structural adaptation in the process of approaching the EU.

Former researches in the field of population geography in Croatia have found that modern demographic development of Croatia is characterized by unfavourable processes and structural features: general depopulation, depopulation of the majority of administrative-territorial units, (bio) reproduction depopulation, rural-urban division, accelerated ageing and a very high percentage of old population. In an interdependent activity the quoted elements of demographic development (and some other, such as out-migration and wars) have

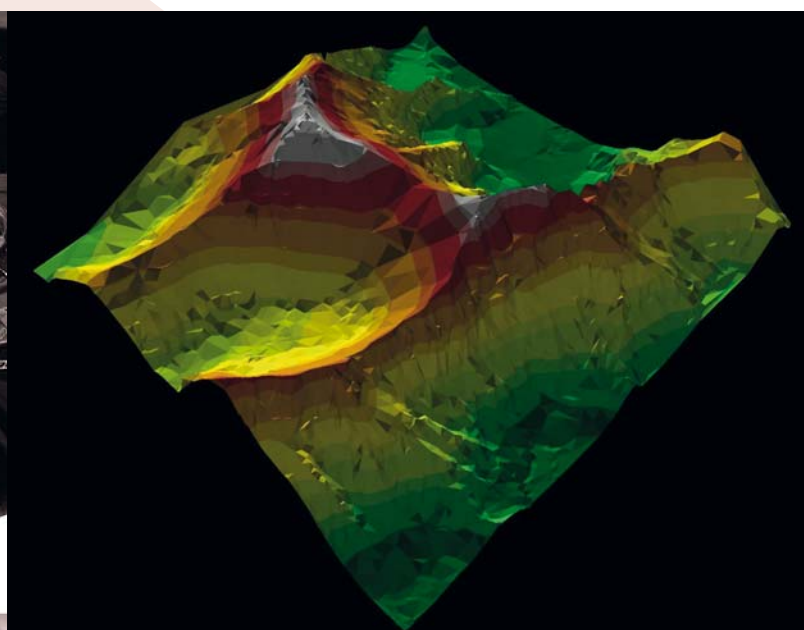
formed a very uneven population distribution in Croatia and unbalanced regional development, as well as deepened the differences between the rural and urban areas, as well as between the outskirts and centres. Therefore, the principal research aim of the project Spatial Features of Demographic Resources in Croatia is identification, evaluation and projection of demographic resources in Croatia and its spatial units. The research focus is in the spatial dimension of demographic resources problems. As Croatia is in front of the integration with the European region, an overall valorisation of its regions is necessary, as well as that of its demographic resources and potentials.

Project Geographical Research of Border Regions of Croatia includes the research of the following four topic contents - the basic natural features of border regions, historical-geographic development, contemporary politico-geographic characteristics and socio-economic features as a consequence of the former development. The project also includes the researches of contested or politically sensitive border regions, but also related politico-geographic or geopolitical contents interesting for our country.

DIVISION OF PHYSICAL GEOGRAPHY

Scientific activity at the Division of Physical Geography, Faculty of Science, primarily proceeds through several scientific projects financed by the Ministry of Science, Education and Sports. The project Geomorphological and Geocological Research of Karst Areas in Croatia researches the geologic structure impact on the origin and development of the karst relief forms. It also deals with the connection of the structural relations on the surface with those inside particular speleological phenomena. The emphasis is on elaboration of the existing and new structural-geomorphologic methods in the GIS setting. The second important aim is determination of absolute and relative amount of karst denudation (corrosion) in selected areas. Simultaneously, microclimatic measurements, soil and plant cover analyses are done in the same locations (especially in dolinas). Microclimatic measurements also take place in caves and pits. The final

purpose is the creation of geomorphologic and geocological data basis in the GIS setting. In the framework of the project Geomorphological Mapping of the Republic of Croatia geomorphological mapping is being done and geomorphological maps of Croatia are made to the scale 1:100 000. All completed geomorphological maps include morphographic, morphometric, morphogenetic and morphocronologic data. Digital analyses





of the relief spatial data and making of final maps are carried out by means of the GIS tools. More than half of Croatia has been mapped so far, and an easy-to-survey geomorphologic map of Croatia to the scope of 1:500 000 is at the final stage of production. On the basis of those researches a detailed geomorphological regionalization of Croatia to the level of subgeomorphological regions has been carried out. A great attention is paid to geoecological evaluation of relief, and also to the protection of valuable relief forms as elements of geo-heritage.

DIVISION OF REGIONAL GEOGRAPHY AND TEACHING METHODS

Research of urban systems under the scope of the project Urban Systems in Croatia's Spatial Development analyses their uneven development, which, in the case of Croatia, has influenced unfavourable spatial processes, such as strong centralization and polarization, as well as a marked rural exodus. This research deals with urbanization characteristics, towns in border areas, small and medium towns, town as a system, spatial structure of towns, spatial organization of economic activities and development of economic zones, real estate market in towns, urban regions, suburban traffic systems and spatial development of Croatia from the aspect of different development concepts (centre-outskirts, polarized development, axes of development, etc.). The aim is to introduce corresponding spatial-planned measures and suggestions with the purpose of the regional and spatial development balance. Research



in the framework of the project Environmental Change and Cultural Landscapes as Development Resource includes two basic discourses: ecological and semiotic. The ecological one is directed towards the processes between nature and the activities of the human society, where the latter are mainly considered a menace to ecological balance. This discourse corresponds to the idea of landscape as natural welfare. Semiotic discourse is directed to social and cultural significance



in landscape formation. This approach corresponds to the idea of landscape as social and intellectual welfare. Cultural landscape is one of basic concepts in geography and one of the most complex ones. The main purpose of the project Space as a Resource for Croatian Tourism Development is the research of space and tourism interrelations. Space is simultaneously a prerequisite of tourism development and a medium in which tourism proceeds, and in time, it is being transformed under the influence of tourism. In that process, if tourism development is not followed by a quality regional planning and management, its vital basis (natural and anthropogenous resources) is very often degraded. Researches will make efforts to define natural and anthropogenous space elements included in the Croatian tourism attraction basis, analyze in which way that same space is being transformed by tourism, and whether that transformation has a positive or negative impact on the space as present and future basic Croatian tourism resource.

Department of Geography – teaching activities

GEOGRAPHY TODAY In the age of globalization, on the threshold of post-industrial society, information becomes one of the key development resources. Research has shown that about 80% of information has its spatial dimension, and contemporary geography is a science which describes and explains patterns in spatial relations. First and foremost it explains the origin and significance of two basic spatial systems – ecological and spatial. With regard to such a wide study topic geography is an especially complex and important science, so it is included in the teaching process as early as the primary school level. Besides, as an interdisciplinary science it is also included in the study of economy, political sciences and natural-scientific subjects having a great deal in common with geography.

UNDERGRADUATE RESEARCH PROGRAMME IN GEOGRAPHY

Undergraduate Research Programme in Geography offers an integrated basic study of systematic geography, consequently a balanced study of natural and social geography. The study lasts three years, and in that period it is necessary to accumulate at least 180 ECTS credits. After a successful graduation, a bachelor can enrol in one of five graduate research programmes at the Department of Geography, Faculty of science. Besides theoretical knowledge in natural and social geography, one should emphasize practical knowledge acquired primarily under the scope of cartography, geoinformatics, methods and theories in geography, as well as of field trips. Undergraduate study ends by passing all exams and making of a final bachelor's thesis. Bachelor of geography (univ. bacc. geogr.) has been qualified for collecting and processing of spatial data in scientific, regional-planning and cartographic institutions and firms, as well as in the government and local administration.

GRADUATE STUDY IN GEOGRAPHY

Graduate Research Programme in Geography, lasting two years, is a continuation of the basic study. Therefore, in that study, the emphasis is on elective courses which take place at the parent department, but also out of it. It is necessary to accumulate at least 120 ECTS credits. A prominent applicable character of study programmes requires student training in partner institutions. Certain specialization in several study programmes has also been anticipated at this stage. Graduate Research Programme in Geography: Physical Geography and Geoecology has a marked geo-ecological approach with a possibility of choosing courses in related fields. Study of Spatial Planning and Regional Development offers specialization in the field of social geography and it is primarily assigned to the students of geography interested in the management of spatial resources. Study of Heritage and Tourism offers a complex study with the emphasis on historical-geographic and cultural-geographic contents and tourist valorisation of space, while the study of Geographical Information Systems is closely directed to the acquisition of

theoretic knowledge necessary for spatial-analytic work, i. e. for the work with the GIS, as well as to the adoption of corresponding skills. Academic title acquired by graduation is master of geography (mag. geogr.). Education study. Apart from the Graduate Education Programme in Geography and History lasting five years (in collaboration with the Faculty of Humanities and Social Sciences in Zagreb), there is a two-year Graduate Education Programme in Geography. During this study it is necessary to accumulate 120 ECTS credits. The study produces teachers of geography in the primary, secondary (gymnasium) and professional schools. Academic titles acquired by graduation are master of education in geography and history (mag. Educ. geogr. et hist.), i. e. master of education in geography (mag. educ. geogr.).

JOINT STUDIES In collaboration with the Departments of Geology and Biology, Faculty of Science, there are common undergraduate and graduate studies of Environmental Sciences taking place at the Department of Geography.



DOCTORAL STUDIES Postgraduate Doctoral Study in Geography has been organized as the highest degree of education in the field of geography and considered as a continuation of education after the finished undergraduate and graduate studies in geography and related disciplines. Besides its scientific (theoretic) component, the postgraduate study under the name of Geographic Elements of Regional Planning has also an applicable one. Every course at the postgraduate study is largely in the function of acquiring special knowledge directed to regional planning. Programme of the Doctoral Study in Geography includes lectures, seminars and a research component. In the first study year and in a part of the second one the emphasis is on teaching contents, and in the third year on scientific-research activities. During the three years of the study a student must accumulate 180 ECTS credits (60 credits per year) and pass all obligatory and elective subjects, as well as do the field trip. Students should publish two scientific works during the second and third years, of which one must be presented at a scientific conference. As a rule, the postgraduate study lasts three years and having finished it, one acquires the academic degree doctor of science, branch geography (Doctor scientiarum naturalium ad geographiam pertinentium).

Department of Geography – other activities

Department of Geography takes part in several extracurricular activities in cooperation with the Croatian Geographical Society. One of the most popular and most well known is geografija.hr, a non-profit educational web portal. The goal of this project is to enhance the communication between geography as a science and profession and public. Popular science articles which approach different issues of the world and society from a geographical standpoint are published regularly, and the web portal registers around 50 thousand clicks per month. Apart from popular articles, there are several other topics and categories (book reviews, quiz, photo gallery, 'Ask a geographer' etc.) This web portal serves not only geographers, students, teachers and professors but everybody who takes interest in the



world around us. Together with the web portal, very popular is the e-school of geography, a part of e-school of young scientists which started in 1997 with a main purpose of bringing science closer to young people, especially students and pupils. Taking part in this project are active scientists and professor from universities, public institutions, teachers from elementary and high schools and people from the economic sector. A part of this all-encompassing project is organized by the Croatian Geographical Society.

PUBLISHING Department of Geography (co)publishes two scientific journals.

Hrvatski geografski glasnik Hrvatski geografski glasnik is a scientific journal of the Croatian Geographical Society and the Department of Geography. The first issue was published in 1929. Today it is a semestral journal covering the topics of natural sciences, geosciences, social sciences, human geography and demogeography.

Acta Geographica Croatica Acta Geographica Croatica is a scientific journal of the Department of Geography, Faculty of Science. The first issue was published in 1958 under the name "Radovi". It changed its name to Acta Geographica Croatica in 1992.

Department of Geophysics

MISSION The Department of Geophysics, an educational and research institution incorporated into the Faculty of Science, provides an excellent education in geophysics (seismology, oceanography, meteorology and geomagnetism with aeronomy) and leads in national and international research projects and programs integrated into educational process. Scientific development of the Department upgrades the scientific competency of the Faculty and consequently the quality of the educational process, the University, and the society as a whole.

VISION The Department of Geophysics is internationally recognized. It represents the centre of the Croatian scientific research in geophysics, a basis for the top quality academic education of the prospective bearers of scientific excellence. The complexity of the scientific challenges in geophysics, and their successful solving, requires the establishment and deepening of collaboration with other branches of natural sciences, as well as mathematics and computer science, to obtain the best and up-to-date results.

DESCRIPTION OF THE DEPARTMENT At the moment, 16 lecturers are involved in the education process at the Department of Geophysics, together with one professor emeritus, 6 assistants and 3 associates. Currently undergraduate study of geophysics and graduate study of physics-geophysics are attended by approximately 80 students. Four classrooms equipped with modern teaching facilities are available for lectures (two 36-seats and one 12-seat classroom and one classroom equipped with a dozen PCs and a fast connection to the internet).

CENTRAL GEOPHYSICAL LIBRARY The Central Geophysical Library is the oldest faculty library in Zagreb. It was established in 1861 and it has been in function continuously since then. The Library stores over 5000 books and textbook titles, 20000 journal volumes and manuscripts, and it covers all geophysical disciplines: seismology, oceanography, meteorology, geomagnetism, and some contiguous areas (astronomy, physics, mathematics, geology, geography, etc) as well.

Horvatovac bb
HR-10000 Zagreb, Croatia
Tel: +385-1-4605 900
<http://www.pmf.unizg.hr/geof>

Department of Geophysics – scientific activities

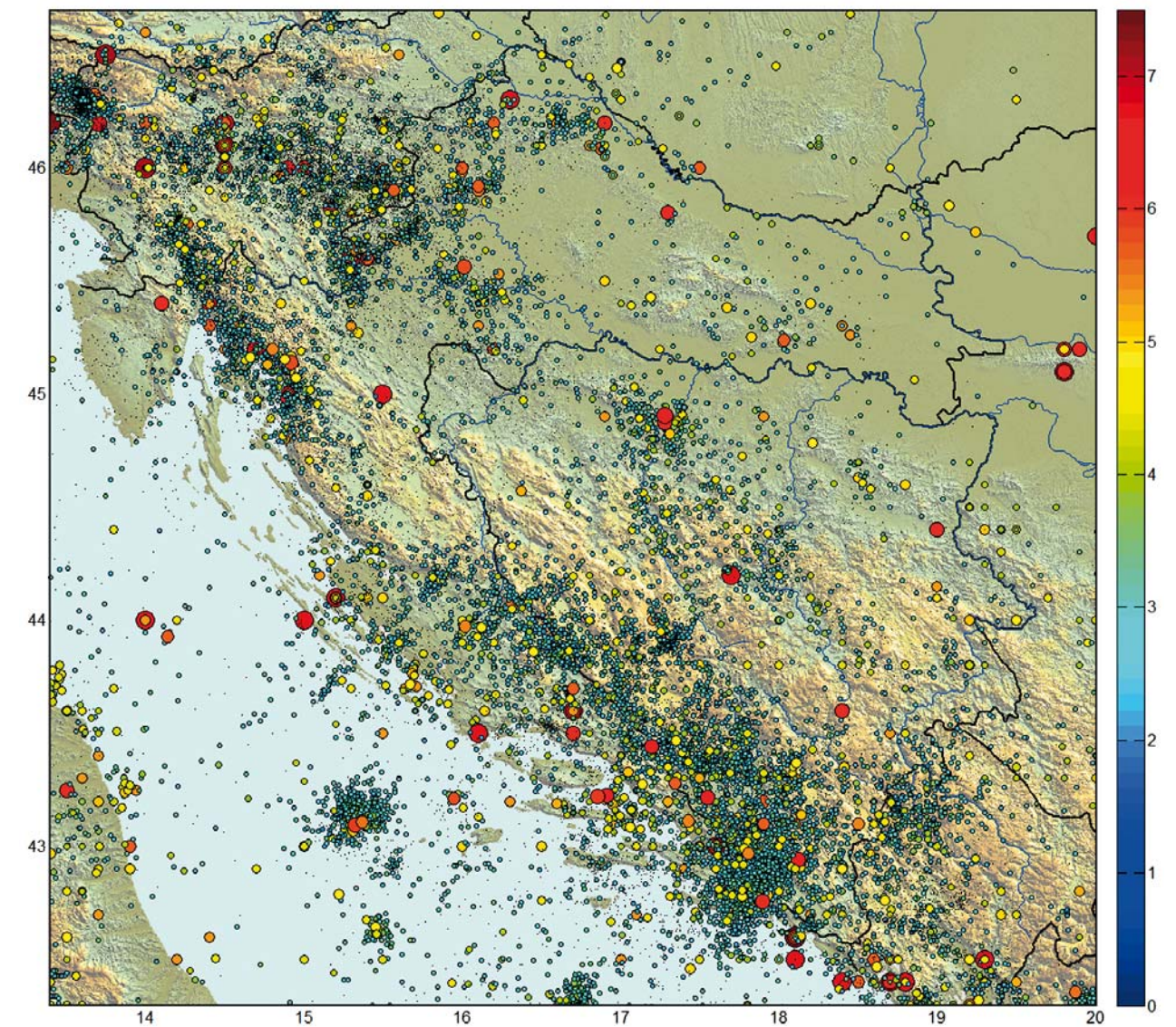
Scientific activities are very diverse in different geophysical disciplines (seismology, physical oceanography and meteorology) and they comprehend geomagnetism, aeronomy and physics of the Solar system as well. The scientific activity is based on the field measurements substantiated by theoretical analyses and also by numerical models. Unlike other physical disciplines, the laboratory work in geophysics is not present to a large extent because the main laboratory of the geophysicists is the Earth. The Earth represents inexhaustible source of themes and ideas for scientific work. Scientific research in geophysics is mainly multidisciplinary, which indicates the complexity and the interconnection of the investigated processes.

Croatia belongs to seismically active regions of the Earth. Therefore, all aspects of Croatian seismicity are regularly explored at the Department of Geophysics, which includes: recording and analysis of earthquakes, determination of their locations, cataloguing and statistical processing. The research based on these data is carried out in several directions: (i) statistical analysis of seismicity and the characteristics of large series of aftershocks in order to assess seismic hazard for the region (through the evaluation of parameters that define the statistical characteristics of seismicity and their reliability); (ii) seismic zoning of Croatia and mapping of seismic risk on the baserock level (or the average soil) for different return periods; (iii) the assessment of amplification properties of the soil surface layers (important for civil engineering); (iv) the analysis of tsunami risk on the Croatian coast (tsunamis = waves that occur during an earthquake in the sea), which is implemented in cooperation with oceanographers; (v) study of the lithospheric structure using receiver functions and surface waves dispersion; (vi) quantification of earthquakes; (vii) the investigation of seismic anisotropy and heterogeneity of the lithosphere (which affects the propagation of high frequency seismic waves causing e.g.

attenuation of seismic energy) with the aim of improving the precision of earthquake locations, as well as the development of new tool in ore deposits exploration. For all of the research mentioned above basic input data are provided by the Croatian network of seismographs and accelerographs maintained by the Croatian Seismological Survey which is an important part of the Department.

Croatia extends to the Adriatic Sea, where interesting physical, chemical and biological processes take place. The Adriatic, a coastal sea, is very sensitive to changes in its environment, so the investigation of interaction between the atmosphere and the sea, and of phenomena related to changing bathymetry and coastline, is of great importance. Such studies demand special meteorological measurements and meso- and microscale numerical modelling of the atmosphere (bora gusts, gravity waves, turbulence). Hydrographic properties, currents and sea level in the Croatian coastal region and their relation to air-sea fluxes, are also examined. The effect of the Adriatic island chain on the propagation of long waves caused by the earthquake-induced seafloor displacements is studied using verified numerical models. The Adriatic-Mediterranean system is sensitive to the surface heat flux, so the response of the system to future (natural and anthropogenic) climate changes is investigated. The results of these investigations are necessary for the preparation of ecological studies that address the distribution of pollutants and, hence, for the protection from pollution (oil, waste water ...). The understanding of the spreading patterns is of great importance for the study of biochemical processes in the sea, and therefore for the study of their impact on the food chain. The investigation of sea-level oscillations, especially those with amplitudes reaching several meters, is relevant for the protection of coastal areas from flooding. Oceans and seas are important absorbers of greenhouse gases so the flux of carbon dioxide in the Atlantic Ocean is also being investigated.

Croatian territory comprises very diverse relief forms which trigger interesting, and not completely explored, atmospheric phenomena over its area. The goal of exploring the atmospheric waves and their interaction with turbulence is to enhance theoretical knowledge and to improve the weather and climate



forecasts. Currently used numerical weather prediction models serve, besides for the forecasts, in different areas of human activities. Some of the essential meso- and microscale processes in our coastal and mountain regions (the three-dimensionality of structures, the non-stationarity and the turbulence of bora wind, jugo, and also the valley, coastal and mountain circulations), which affect both the environment and population, are investigated on the basis of regularly available meteorological data, and of special measurement campaigns. These current investigations have the aim of better predicting the local weather phenomena and understanding and projecting the micro-climatic variations in the future. The turbulence is still rather unknown meteorological phenomenon, encouraging investigations of the turbulence properties of the atmospheric boundary layer over Croatia's complex terrain by the high-frequency measurements of the wind and temperature. The influence of ENSO on the climatic characteristic of Europe is studied by a numerical atmospheric global circulation model. A coupled atmosphere-ocean model is used for investigating the influence of global warming, related to the increased concentration of greenhouse gasses, on the remote connections of climate over tropical Pacific, north Atlantic and Europe. Investigations on improving the air quality in Croatia on different

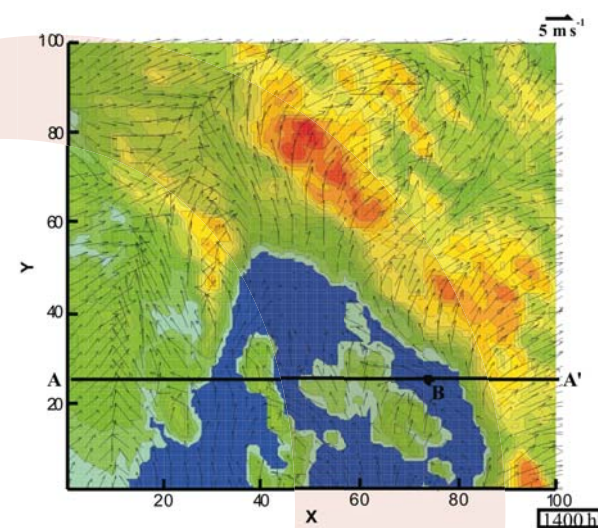
spatial and temporal scales are also pursued at the Department. The application of existing approaches does not secure sufficiently good estimations of pollutant concentrations. The new system of combining meteorological with chemical models is about to be established, which will be equally applicable for inhomogeneous surfaces, for complex topography and for smaller spatial scales. The structure, dynamics and turbulent characteristics of the atmospheric flows over the complex topography are investigated, as well the influence of traffic and industry on the air quality. The role of specific weather conditions (e.g. thermally induced mountain and sea-breeze circulations, bora, jugo, pollutant plume meandering at low wind speeds, etc.) in the life cycle of the atmospheric pollutants is also studied. The investigations described are directed to the improvement of the air-quality predictability in Croatia on a smaller spatio-temporal scales, which is important in legislative and planning and is related to the existing (and possible) individual sources of pollution under different meteorological conditions. Recently, the research on the geomagnetic field in Croatia was re-commenced after several decades. The information on the geomagnetic field distribution is important for the security of air and navy traffic. Measurements of geomagnetic elements are also used in the identification of minerals, and provide a

helpful tool for oil mining and for the reduction of data obtained during ground surveys in geodetic measurements. An effort to establish the geomagnetic observatory is an ongoing process with the aim to augment the INTERMAGNET, the global network of observatories. The final aim is to continuously measure the geomagnetic field, a prerequisite for significant scientific development.

All investigations mentioned above are closely connected with the educational process at the Department. Students are often included into different forms of interactive collaboration (carrying out field measurements, analysis and interpretation of data) and are thus improving their skills.

Department of Geophysics – teaching activities

Geophysics today Geophysics is the science whose subject of interest – the Earth – continuously and always afresh inspires the researchers and the scientists. Tradition of geophysics in Croatia is a long-standing one, and dates well back into the 19th century. Andrija Mohorovičić – the greatest Croatian scientist of all times, internationally renown for the discovery of the boundary between the Earth's crust and mantle – was a director of the Department for over 30 years in the beginning of the 20th century. Unfortunately, unlike most scientific disciplines (biology, chemistry, physics, etc.), geophysics is not included into educational programs of secondary schools, let alone the elementary school. The geophysical terms are introduced to the young generation through the subjects of other natural disciplines, principally geography. In spite of all this, geophysics is a science that develops rapidly often thanks to natural (or anthropogenic) phenomena with catastrophic consequences. The damage mitigation, as well as the sound prevention measures, are directly dependent on the knowledge of the processes which occur in the Earth's interior (earthquakes), as well as on its surface (oceans and atmosphere). Today, the good



quality of life and safety are inconceivable without the results of expertise from different disciplines: from weather forecasts, bio forecast, air and sea quality forecasts, sea level and currents forecasts, magnetic elements for safe traffic to seismic parameters required for application of antiseismic building codes. Climate change, environmental protection, prevention and mitigation of impact of extreme events, are just some of the driving forces for the development of geophysics. The success of geophysics lies in its multidisciplinary character (not only within the branch, but including other scientific disciplines), which allows an understanding of very complex physical processes within the Earth. Our students at the undergraduate, graduate and Ph. D. levels are trained to solve such challenges in the future.

Undergraduate study of geophysics The duration of study is three years, during which it is necessary to collect at least 180 ECTS credits. The third year of the undergraduate study follows up the first two years of the study of physics. It is also possible to enrol in the study from other studies organized by the Faculty of Science, or from the Faculty of Electrical Engineering and Computing, with possible obligatory differential exams. After

successful completion of the undergraduate study, bachelors have the possibility to enrol the graduate study programs at the Department of Geophysics. The bachelors achieve fundamental knowledge of the physical basis of geophysical disciplines, as well as the necessary skills for professional and technical tasks: performing measurements, maintenance and calibration of instruments, data acquisition and basic interpretation, routine analyses of geophysical data, data archiving and field work (e.g. macroseismic field work). The knowledge and skills acquired should enable them to continue their studies, not only in geophysics, but also in other disciplines. Academic title acquired after completion of the undergraduate study of geophysics is Bachelor of Geophysics.

Graduate study of physics – geophysics The duration of graduate study is two years, during which it is necessary to collect at least 120 ECTS credits. This program naturally follows the undergraduate study of geophysics. Enrolment is also possible from other undergraduate programs organized by the Faculty of Science, or from the Faculty of Electrical Engineering and Computing, with possible obligatory differential exams. Besides all the competencies gained at the undergraduate level, the graduate program offers detailed, fundamental theoretical and practical introduction to the basic geophysical disciplines (meteorology, physical oceanography, seismology, geomagnetism and aeronomy). The graduates will gain knowledge and competencies needed for entering Ph. D. program and/or to initiate their scientific careers in the chosen area of specialization: meteorology and physical oceanography or seismology and physics of the solid earth. Study offers numerous optional courses, and after all the exams are passed it is necessary to write and defend a thesis with the topic from the chosen discipline. Academic title acquired after completion of this graduate study is Master of Physics – Geophysics. At the Department of Geophysics different courses are held for students of other departments (Geography, Geology and Biology) of the Faculty of Science, Zagreb. Our teachers also hold courses at other faculties of the University of Zagreb and at the University of Split.

Doctoral studies During this study the candidates acquire knowledge and skills in research methods that lead to their full autonomy in scientific and research work. The study is based on the research in the frame of ongoing projects and under the leadership of mentors. To a smaller extent, it is carried out also through formal teaching in form of lectures and seminars. Lectures and seminars have a role to expand and deepen the knowledge related to the topic of doctoral research and they assume regular consultative forms of teaching. Doctoral study of geophysics is open primarily to graduate students of geophysics, but it is also available to students of compatible disciplines. The duration of doctoral study is at least three years with average annual load of 60 ECTS credits. The courses comprise obligatory (Data Analysis in Geophysics, Geophysical Seminar and Doctoral Seminar) and optional subjects. Other courses cover the main geophysical disciplines. The study is completed after successful defense of the thesis, which is supposed to be written in the frame of the ongoing project at the Department of Geophysics or any other scientific institution with established collaboration with the Department. Academic title acquired after completion of this doctoral study is Doctor of Natural Sciences in the Field of Physics (Geophysics).

Department of Geophysics – other activities

Seismological Survey of the Republic of Croatia Seismological Survey of the Republic of Croatia operates in the framework of the Department of Geophysics, and



covers macroseismic and microseismic data acquisition and processing. The instrumental data are provided by the network of 15 digital seismological stations and more than 20 accelerographs deployed on the Croatian territory. Their task is to observe and analyze the ground vibrations caused by the local or world-wide earthquakes. Based on the earthquake recordings the information about strong earthquakes is distributed to local population and professional expertise is provided to builders, insurance companies, etc.

Popularization of geophysics

Starting from a few years back, the organized visits for elementary and secondary school pupils, students and citizens take place at our Department with the aim of popularization of geophysics. The visitors are introduced to geophysics as a science that covers various processes at the surface and in the interior of the planet Earth through popular lectures and interactive experiments. Very often the memorial rooms of Andrija Mohorovičić, internationally renowned Croatian seismologist and meteorologist, arouse the greatest interest. There, the instruments and other exhibits tell the story of seismology and meteorology of over a century ago.

Publishing activity

Since 1984, Andrija Mohorovičić Geophysical Institute publishes the journal GEOFIZIKA (<http://geofizika-journal.gfz.hr/>), which succeeds the previous series RADOVI (published since 1923). At the beginning GEOFIZIKA was published annually, and from 2006 semi-annually. Since 2007 articles from GEOFIZIKA are referred in the SCIE base (Science Citation Index Expanded). GEOFIZIKA publishes contributions dealing with physics of the atmosphere, the sea and the Earth's interior.

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Davor Kovačević

Responsible editor:
Amir Hamzić

Editorial board:
Damir Bakić
Denis Sunko
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